The
ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XII No. 7. JULY, 1951

UNIVERSITY OF MICHIGAN
AUG 6 1951
ENGINEERING LIBRARY

Churchill

THE high rates of output and the degree of accuracy obtainable on the Churchill 'Fulcro-Sizer' Automatic Plain Grinders are a revelation even to those accustomed to producing fine tolerance work on a manufacturing basis.

THE CHURCHILL MACHINE TOOL COMPANY LIMITED, BROADHEATH, MANCHESTER

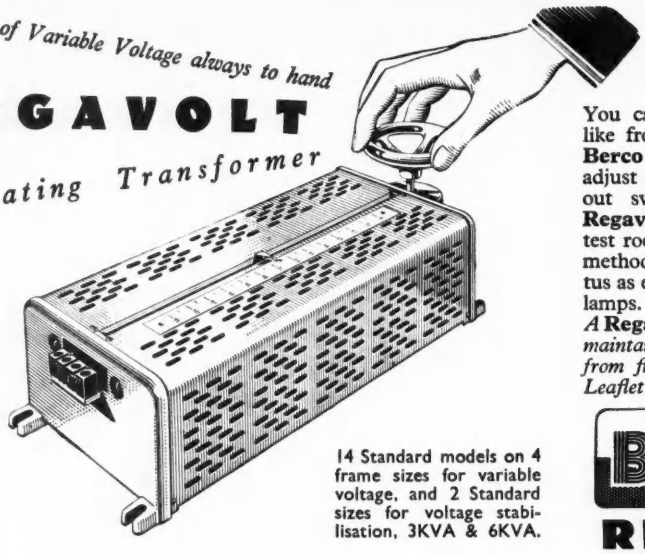
Export Sales Organization ... ... Associated British Machine Tool Makers Limited, London, Branches and Agents.
Home Selling Agents ... ... Charles Churchill and Company Limited, Birmingham and Branches.

PRECISION *plus* PRODUCTION

A source of Variable Voltage always to hand

REGAVOLT

Regulating Transformer



14 Standard models on 4 frame sizes for variable voltage, and 2 Standard sizes for voltage stabilisation, 3KVA & 6KVA.

You can obtain any voltage you like from an A.C. supply with a **Berco Regavolt.** You can also adjust the voltage smoothly, without switching off the load. A **Regavolt** is indispensable in the test room and is the most efficient method of controlling such apparatus as electric furnaces, motors and lamps.

A **Regavolt** *is particularly useful for maintaining a constant supply voltage from fluctuating mains. Write for Leaflet* 605

BERCO

REGAVOLT

Regulating Transformer

THE BRITISH ELECTRIC RESISTANCE CO. LTD. Queensway, Ponders End, Middlesex.

Telephone Howard 1492 Telegrams: Vitrohm Enfield

BR3072-TH

---

now

WRITE FOR A NEW BOOKLET

"Cronite" RECO. TRADE MARK

The **HIGH TEMPERATURE ALLOY**

SALT, LEAD AND CYANIDE VESSELS
CARBURIZING BOXES AND POTS
ROTARY RETORTS & PROPELLING WORMS
FURNACE HEARTHS AND FITTINGS
ENAMELLING PERRITS AND SUPPORTS
GLASS-BLOWING NOZZLES
PYROMETER PROTECTION SHEATHS
CASTINGS FOR USE AT 700°/1200° C.

The **CRONITE FOUNDRY Co. LTD**

LAWRENCE RD · TOTTENHAM · LONDON N15

PHONE · STAMFORD HILL 4237

CONTENTS

	Page
The Blue Pages	207
Russia's Mineral Potential	211
Deep Drawing from Heavy-Gauge Steel Plate	212
Metal Spinning	215
The Use of Torsion Bars in Guillotine Shears	217
On the Mechanism of Disruption of High-Alloyed Steels During Forging	218
Further Improvements of Known Methods of Fault Location	220
A New Electrolytic Polishing Method for Metallographic Investigations of Si-Rich Light Alloys	222
High-Temperature Problems in Aircraft Jet Engines and Turbo-Superchargers	223
New Trends in the Design of Metadyne Generators	225
Determination of the Fatigue Limit of Metals by Means of a Three-Ring Test Machine	230
New Materials, Processes and Equipment	231
Classified Abstracts	234
News of the Month	236

The ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XII. No. 7 JULY, 1951

EDITORIAL AND ADVERTISING OFFICES:

GREAT BRITAIN
120 Wigmore Street, London, W.1.
Telephone: WELbeck 9357 & 6263

U.S.A.
366 Madison Avenue, New York 17, N.Y.
Telephone: MUrray Hill 2-8865

FRANCE
93 Champs-Élysées Paris, (8e)
Telephone: Élysées 09-03

Annual Subscription Rates:
£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area.

Printed in Gt. Britain by ROBERT STOCKWELL LTD., 5-11 Baden Place, London, S.E.1, and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

pitman

Engineering Design
By J. E. TAYLOR, M.Sc.Tech., A.M.I.Mech.E., and J. S. WRIGLEY, M.Sc., A.M.I.Mech.E. A well-known work for Degree and professional students. Third Edition. 18/- net.

Electrical Engineering Theory and Practice (3 vols.)
By PHILIP KEMP, M.Sc.Tech., M.I.E.E.; assisted by over 40 contributors. A notable new work, forming an up-to-date library of information on all aspects of electrical engineering. Nearly 2,000 quarto pages; over 2,000 illustrations. Per set £10 net.

Displacement Pumps and Motors
By R. HADEKEL, B.Sc., A.C.G.I., A.F.R.Ae.S., A.M.I.Mech.E., Consulting Engineer. Examines the theoretical basis of the various mechanisms and the constructional problems involved and describes their practical applications. 177 illustrations. 25/- net.

Designing for Mass Production
By J. R. FAWCETT, B.Sc., A.M.I.Mech.E. Second Edition. 15/- net.
"Presents a veritable mass of information regarding materials and standard specifications . . . will serve as a most useful reference."—MECHANICAL WORLD.

Hydro-Electric Engineering
By GEOFFREY GERARD, F.R.S.E., A.M.I.E.E. Includes useful information on existing schemes and plant. 101 illustrations. 20/- net.
"An interesting over-all survey of a vast subject."—ENGINEERING.
"Can be recommended."—CIVIL ENGINEERING.

Engineering Tolerances
By H. G. CONWAY, M.A., A.M.I.Mech.E., F.R.Ae.S. A comprehensive study of the subject, with full tables of all recognized and published tolerance systems, and guidance on their effective use. Over 100 illustrations, 30/- net.

Intermediate Engineering Drawing
By A. C. PARKINSON, F.I.E.D., A.C.P.(Hons.), F.Coll.H., F.Inst.Mech., etc. Third Edition, revised and extended. 402 illustrations. 9/- net.
"The author and publishers are to be congratulated."—TRANSACTIONS OF THE INSTITUTE OF MARINE ENGINEERS.

Air Compressors, Control and Installation
By P. C. BEVIS. Includes a full survey of the problems of cooling, moisture separation, and the layout of air mains, information on safety devices, etc. With nearly 100 illustrations. 20/- net.

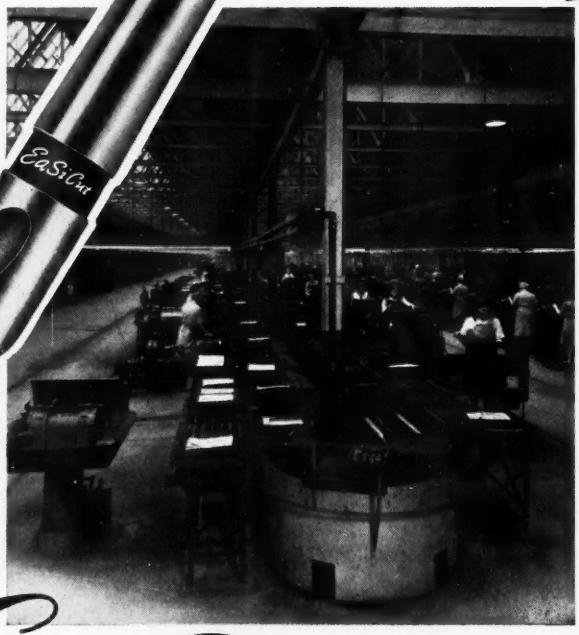
Echo Sounding at Sea
By H. GALWAY. A guide to basic principles and present-day techniques, with a detailed account of the Hughes and Marconi types of equipment. Illustrated. 35/- net.

The Practical Engineer Pocket Book, 1951
Edited by N. P. W. MOORE, B.Sc., A.C.G.I., D.I.C., A.M.Inst.F. A famous pocket book, now in its 63rd year of publication. With Technical Dictionaries in German, French and Spanish. Over 750 pages. Illustrated. 8/6 net.

SIR ISAAC PITMAN & SONS, LTD., *Parker Street, Kingsway, London, W.C.2.*

Announcing

The view on the right shows a section of our new flow production plant for "Easicut" drills.



EaSiCut

The NEW High Performance DRILL

We produce vast quantities of high-grade (alloy) steels and supply them to a wide circle of users, including our associated factories.

In these factories and elsewhere, not the least in our own extensive machine shops, we gain unrivalled experience in machining these same steels.

Since the days of Sir Joseph Whitworth we have practised the art of making tool steels and fashioning them into cutting tools of distinction.

It is not surprising that such resources and such breadth of experience should evolve the "Easicut" drill.

Makers of high quality Engineers' Cutting Tools for over a ¼ century

ESC

ENGLISH STEEL CORPORATION LTD
OPENSHAW MANCHESTER

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *GLASS-LINED PIPING*

For the conveyance of corrosive fluids in the chemical industries, the employment of glass-lined pipe has witnessed a steady increase in recent years; and this in spite of the fact that the technique of pipe fabrication and assembly still showed certain shortcomings. One of these was that glass-lined piping for highly corrosive conditions had to be joined by flanges of the Van Stone type. Certain services, particularly in the petroleum industries, however, require the use of couplings rather than large-diameter flanges. Connections with the use of couplings can now be made by a new type of joint which permits the use of corrosion-resistant alloy pipe couplings. In this scheme, two short alloy rings are welded to the ends of a length of low-carbon steel tubing. The glass lining is then applied by conventional means and terminates at either end of the alloy ring. Following the application of the glass lining, the pipe is threaded and can then be connected by the alloy fitting. Another shortcoming which affected the ease of installation of glass-lined pipe in the past was the inability of the user to produce make-up lengths of pipe on site. Pipe lengths therefore had to be supplied in exact lengths for installation, and any errors in specifying proper pipe lengths or alterations in layout caused considerable delays. This difficulty has now been overcome by the design of a porcelain adaptor with a thin steel jacket and two threaded steel flanges. Both the porcelain adaptor and the jacket can readily be cut, thus making it easy to produce any required make-up length on site.

● *GASEOUS ANNEALING OF MALLEABLE CASTINGS*

The gaseous annealing of whiteheart malleable iron has made rapid progress during the last five years. This malleablizing treatment consists of heating the castings to a temperature of about 1050° C in an atmosphere which will decarburize the iron without oxidation. This process was formerly carried out by packing the castings with iron ore in boxes and then holding the boxes at the malleablizing temperature for the requisite annealing time. The iron ore acted as a source of oxygen, thus removing the carbon from the castings. Today, it is possible to generate the decarburizing gas within the furnace chamber from air and steam, thus making an ore packing unnecessary. This comparatively new process has considerably shortened annealing time, and has resulted in greater cleanliness of operation and better control. Electrically heated furnaces of the elevator type have proved especially suitable for carrying out the process. The annealing chamber is mounted above the floor level on a structural steel framework, and consists of a rectangular gas-tight steel casing containing the heating elements. The charge is carried on a movable bogie, which is loaded at floor level and then elevated into the furnace. The bogie carries a sand seal which engages with a skirt on the furnace. The same type of furnace can be used for malleablizing blackheart cast iron, but the annealing cycle is different and includes a top temperature soak to effect primary graphitization and slow-controlled cooling through the critical range to effect secondary graphitization.

● *NOVEL FLEXIBLE COUPLING*

The large number of flexible coupling designs in use testifies to the widespread use of such couplings in cases where power is transmitted from one revolving shaft to another. In fact, such couplings are ample evidence of the difficulty experienced in precluding slight occasional misalignment of coupled shafts, both linear and angular. A new type of flexible coupling, in which the flexible member is formed by endless cable links, is claimed to be capable of transmitting high torques between shafts having as much as five-degree angular misalignment. A seven-inch diameter coupling of this type which was tested under a 3-hp pulsating load at 85 rpm is reported as having shown no measurable wear after 700 hours of operation. Important features of the design of the cable links appear to be simplicity of adjustment and ability to absorb shock and torsional vibration. The problem of re-establishing the desired link tension if and when wear has occurred in the linkage system has been solved in a simple and effective manner. Each flange of the coupling has four bolts, which are alternately spaced with the four bolts of the other flange, a link connecting adjacent associated bolts of the two flanges. Each bolt has two split brass eyes with chamfered bores and four tapered washers which are so mounted that tightening of the bolts increases the diameter of one or both of the eyes, witn a consequent tensioning of the cable link concerned.

Will Infinitely Variable

TORQUE CONVERSION

solve the problem?

There are limitless applications for Brockhouse Hydraulic Torque Converters, not only in Motor Vehicles, but in fork-lift trucks, airfield tractors and many other forms of mechanical handling. The advantages of these special power transmission systems are immense, and Brockhouse—who pioneered hydro-kinetic torque conversion—have experts ready to advise you in such matters.

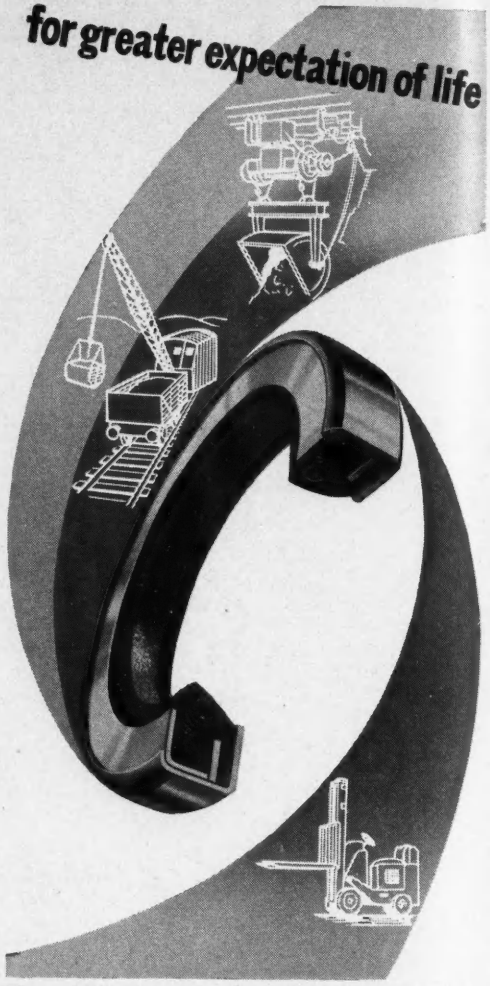
Write to:

BROCKHOUSE ENGINEERING

(SOUTHPORT) LTD.

CROSSENS · SOUTHPORT · LANCS.

London Office: 25, HANOVER SQUARE. W.1

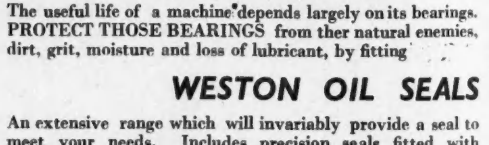


The useful life of a machine depends largely on its bearings. PROTECT THOSE BEARINGS from ther natural enemies, dirt, grit, moisture and loss of lubricant, by fitting

WESTON OIL SEALS

An extensive range which will invariably provide a seal to meet your needs. Includes precision seals fitted with leather or synthetic rubber inserts.

Write or phone for full information.



CHARLES WESTON & CO LTD IRWELL BANK WORKS DOUGLAS GREEN PENDLETON SALFORD 6 Phone PENDLETON 2857-8-9

Birmingham: Midland 6952 London: Holborn 0414

P806

● *STUDY OF CORROSION PHENOMENA*

In order to facilitate the evaluation of the effects of corrosive solutions, a method has been evolved which is similar to television scanning and permits detection, study, recording and analysis of corrosion phenomena. The new method of observation is based upon the fact that corrosion is caused by thousands of local cells formed on the surface affected, these cells being similar to microscopic galvanic batteries. These cells are constituted by the corrosive chemical and the metal itself. By studying the action of these minute electrical cells, much information regarding the fundamental nature of the corrosion phenomenon can be obtained. In the scanning device employed, the laboratory example on which corrosion occurs is a metal cylinder. This cylinder is dipped in some corrosive solution such as sea water, rotated several hundred times a minute, and scanned with a stationary probe electrode. The probe electrode, which is a plastic arm containing eleven silver wires, is placed about 0·02 in. away from the wetted cylinder, so that it can pick up the minute electrical currents accompanying the corrosion process. These currents are amplified electronically and visually observed on an oscilloscope screen or photographed for later analysis. A particular advantage of this method is that it permits easier and faster study of the entire surface area of a corrosion sample. The new technique can be used for investigations of cathodic protection, corrosion inhibitors, stress corrosion, and in fundamental corrosion studies.

● *ISOTHERMAL AIR COMPRESSION*

It is a universally recognised maxim that in air compressor practice, every effort must be made to effect compression with a minimum rise of air temperature. In the ideal compressor, air would be compressed isothermally, thus requiring the theoretical minimum of work of compression. In earlier types of compressors of the reciprocating kind, wet compression was used, but because of the mechanical difficulties encountered and the low piston speeds required, this method was abandoned in favour of intercooling between stages, as is also common practice in centrifugal compressor plant. A recent proposal relates to a system of wet compression in which the air to be compressed is introduced through nozzles into a fast-flowing stream of water, which is discharged into a pressure vessel, in which the air is separated from the water. The proposed plant employs a centrifugal pump for the handling of the water, the air induction nozzles being placed in the discharge scroll of the pump so that the air is forced with the water into the separator vessel from which the compressed air is discharged, while the water after cooling is returned to the inlet side of the pump. It is proposed to use a number of such compression stages in series, each stage having its own water circuit. The principle of hydraulic compression is, of course, not new, and hydraulic compressors of the Taylor type employing the free fall of water are known to have shown high compression efficiencies.

● *NEW GRINDING BAND TOOL*

The introduction of a grinding band, the use and applications of which resemble those of a bandsaw, makes it possible to execute vertical precision grinding on inside, outside and contour cuts in hardened metals. It is claimed that this new continuous line-grind band considerably reduces the limitations on depth and length of cut, as well as on contour shaping, to which operations of this nature were hitherto subject. The new band tool consists of a tough alloy band, to which cubical moulded abrasive matrices are welded. The abrasive is so composed that in its cutting action, there is an equalized balance between bonding and abrasive grits which gives the material a constant degree of abrasive exposure. Line-grind bands of this type are made in two types and two grit sizes which cover a wide range of applications and many different types of hardened materials to be worked. One type of band is provided with abrasive matrices of aluminium oxide. This is recommended for grinding and cutting heat-treated alloy steels, heat resistant steels and wear-resistant non-ferrous alloys. The other type, which is a band provided with silicon carbide matrices, is recommended for grinding and cutting such materials as glass, quartz, marble, granite, etc. Machines equipped with the new grinding band can be used for repairing broken dies by cutting out the damaged section. It is stated that six minutes are required to remove one square inch of special die steel hardened to 59 Rockwell C hardness.

● *MEASURING ADHESION OF ELECTRO-PLATING*

The adhesion of an electrodeposit to base metal is an important factor in the serviceability of the coating. While adherent coatings cannot be removed by any ordinary mechanical means, those with a lower degree of adhesion may either peel spontaneously or become detached if the plated object is flexed or abraded. Less adherent coatings are also more susceptible to corrosion, which spreads readily through scratches and imperfections in the surface. Although a high degree of adhesion can be readily obtained by proper cleaning and pretreatment of the parent metal, adherent coatings cannot be conveniently and consistently mass-produced without effective laboratory control. Several methods have therefore been suggested for measurement of the adhesion of electrodeposited coatings in commercial production. None of these, however, appears to have been generally applicable. A simple and inexpensive method for determining the adhesion of electrodeposited coatings has now been proposed

"airflo"

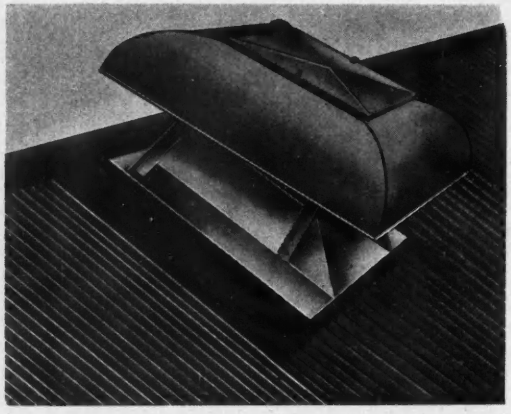
FAN POWERED VENTILATOR

EASILY FITTED TO ANY ROOF

18" FAN — STANDARD SUPPLY 400 V. 3 ph. 50~. — 3900 cfm

£27/5/- EX WORKS

Subject to current raw material prices.



ALUMINIUM BODY—COMPLETELY WEATHERPROOF

Full Particulars on Request

DUST FUME AIR CONDITIONING
VENTILATING PLANTS.

INDUSTRIAL FAN & HEATER COMPANY LIMITED.

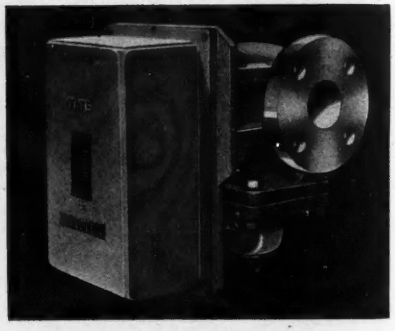
EVELYN ROAD · SPARKHILL
BIRMINGHAM 11.

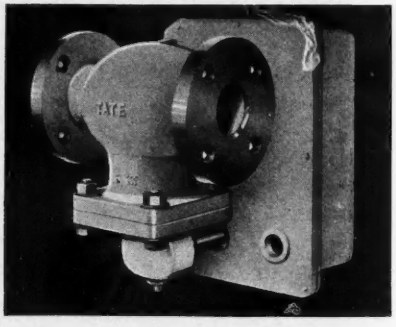
Telegrams: AIRFLO. **Telephone: VICTORIA 2277/8/9.**

Northern Area
22 CITY BUILDINGS, 69 CORPORATION ST., MANCHESTER 4
Telephone: BLACKFRIARS 6918

TATE

SOLENOID OPERATED SEMI-BALANCED DC VALVES AC





For use on
STEAM, WATER, AIR, GAS, SPIRITS, OIL, CHEMICALS, ETC.

SIZES: ¼", ⅜", 1", 1½", 2", 3", & 4"
Pressure Range: 5 lbs □" to 200 lbs □"

JONES, TATE & CO. LTD.
VICTORY WORKS
BRADFORD
'PHONE: 28348/9 *'GRAMS: VALVE.*

and, as it appears, successfully tested. The new technique involves the building-up by electro-deposition of an adherent mushroom-shaped nodule on the surface of the coating to act as a grip for the application of a detaching force. The force required to pull off the nodule together with a portion of the coating is then determined on a spring balance.

● *ELECTROSTATIC GENERATOR FOR ELECTRON MISCROSCOPE*

In electrostatic generators built in the form of influence machines, the purely mechanical transport of electrostatic charges is a function of the velocity and the surface density of electrification of the carrier surface. It is well known that the maximum surface density of electrification is governed by the dielectric strength of the ambient medium. In the case of air, the maximum surface density is some 8 CGS units, and well-constructed electrostatic generators actually operate with densities up to 6 CGS units. With the special belt system employed in electrostatic machines of the van de Graaff type, surface densities as large as 20 CGS units have been reached by employing the artifice of placing the electrostatic field of the surface charges almost wholly into the solid dielectric of the belts. In view of the inherent advantages of the van de Graaff machine, an attempt has been made to utilise the experiences gained with this machine for the design of a disk-type machine. In the newly evolved machine, two eccentrically arranged disks of insulating material, 3 mm thick and about 10 inches in diameter, mutually overlap a relatively small part of the peripheries, with an air space of 1 mm between them. With the disks turning at 1850 rpm in opposite directions of rotation, a voltage of 250 kV with a current of 400 microamps was obtained, and in an atmosphere saturated with tetrachloride of carbon, 410 kV with 500 microamps was obtained. This machine is now being used in conjunction with an electrostatic electron microscope.

● *CUTTING TOOL AS CHEMICAL REACTOR*

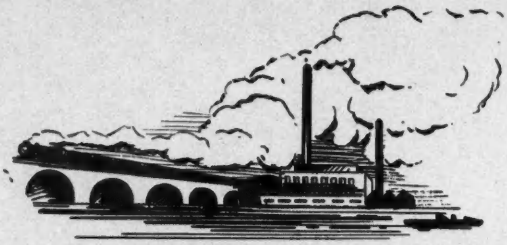
It was discovered some years ago that in machining operations, cutting tools are capable of producing a chemical reaction in the coolant employed. Thus, in cutting aluminium, carbon tetrachloride coolant can be turned into aluminium chloride when passing over the cutting edge. An American concern is now producing reactors for the synthesis of chemicals on a commercial basis. The units consist of a reaction chamber which houses a motor-driven cutter and a rod of metal which is mechanically fed to the cutter. At the point where the cutting tool bites into the metal, the latter is exposed to a very high mechanical compressive stress combined with high frictional heat acting upon a freshly exposed metal surface. It appears that these conditions combine to make the metal particularly susceptible to chemical attack. The chips peeling from the metal rod combine with the chemical reactant in the bottom of the reaction chamber. The chips are used up as fast as they fall, so that there is no excess metal to carry the reaction beyond the control point. It is a matter of speculation whether this phenomenon could not be exploited to accelerate the cutting process itself. Considering the increase in the cutting rate achieved by the employment of powder injection in the cutting of stainless steel, it would certainly appear worth while investigating the possibility of speeding up the machining of such materials by deliberately produced chemical reaction at the cutting point.

● *MAGNETIC SHEET SEPARATOR*

A magnetic sheet floater which serves to separate a stack of steel sheets by means of repelling magnetic fields makes it easy for punch-press operators to lift a sheet from the top of a stack and feed it into the press. This device, which was recently placed on the market in the United States, incorporates a number of Alnico permanent magnets which are attached to a non-magnetic stainless steel wearing plate. Each unit is fastened to the surface supporting the sheets, which are placed alongside the magnet system with a small air gap. As the steel sheets assume identical polarity, they repel each other and separate at distances from $\frac{1}{8}$ to $\frac{3}{4}$ in., depending on their individual weight. As one sheet is taken off the pile, the underlying sheet floats up, and so on in succession. Sheet floaters cut down feeding time, reduce cuts on the hands, and lower glove expense. The arrangement of sheet floaters to be used depends upon specific requirements. For separating circular blanks, for instance, two sheet floaters are placed perpendicularly to each other and tangentially to the stack. Where small sheets are to be handled, they are placed on opposite sides of the stack where the whole sheet is raised across its width. For larger and heavier sheets, the magnetic floaters are placed a short distance from one of the corners.

● *NEW COATING FOR MAGNESIUM*

The development of a new protective coating for magnesium is reported from America. The outstanding characteristics of this coating are claimed to be its excellent corrosion resistance, high melting point, and good dielectric strength and hardness. The coating is normally brown in colour and constitutes an excellent paint base. It is applied electrolytically in much the same way as aluminium alloys are anodized and can be applied to any of the commercial magnesium alloys, wrought or cast. Salt spray tests for 90 hours produced no corrosion, and no corrosion occurred for up to 4500 hours when the coated surface was



HOUGHTO SOLV "W"

QUICK ACTING OIL-FUEL ADDITIVE
FOR **INDUSTRIAL** AND **MARINE** USE

MAKES SLUDGE BURNABLE AND
KEEPS THE SYSTEM CLEAN

A product of

Edgar Vaughan & Co. Ltd.

BIRMINGHAM 4, ENGLAND

Research Service

**WORKS: BIRMINGHAM, LIVERPOOL
BRISTOL**

**MANCHESTER, SOUTHALL
GLASGOW**

waxed. The coating is approximately 0·001-0·0015 in. thick, depending on the length of treatment. A coating 0·001 in. thick will resist an electrical potential difference of 550 volts at 60 cycles. It is therefore probable that insulators will not be required between a joint of magnesium with a different metal, provided that the magnesium surface has been processed by the new method. The galvanic corrosion resistance of the coating has been the subject of limited tests, in which aluminium, zinc, steel and copper discs were assembled in contact with both sides of coated magnesium panels. After five hours' exposure to salt spray, the magnesium surfaces showed no signs of corrosion. The magnesium surface with the coating is claimed to resist temperatures above 1371° C, but as the melting point of magnesium metal is 650° C, this property of the surface coating does not seem to be of much practical importance. It is expected that the cost of applying the coating will approximate to that of anodizing aluminium.

● *CATHODIC ETCHING EQUIPMENT*

The development of a new type of high-vacuum equipment for cathodic etching of metals for the purpose of structure examination has been announced. The new etcher employs the principle of cathodic etching in which the specimen to be studied is bombarded with a glow discharge at a certain high vacuum. The opinion has been expressed that this equipment will be especially useful for studying cold flow lines. The glow discharge which etches the surface of the metal to be examined is produced by positive ions passing between an aluminium anode and the surface of the specimen. The advantage of this technique appears to lie in the feature that the etching is produced physically rather than chemically, so that there is less danger of forming oxides and other chemical artifacts. Under the bombardment of ions, the grain boundaries in the metal are attacked at a different rate from that at which the main bodies of the metal crystals are attacked, which in many cases serves to bring out the crystal shapes and other characteristics of the metal with greater clarity than is possible in an acid etch. It is expected that the new etcher will be used extensively for pure research in metallurgy, as well as in production sampling. The new method may possibly prove particularly useful in cases where chemical etching proves either unsuitable or is difficult to carry out.

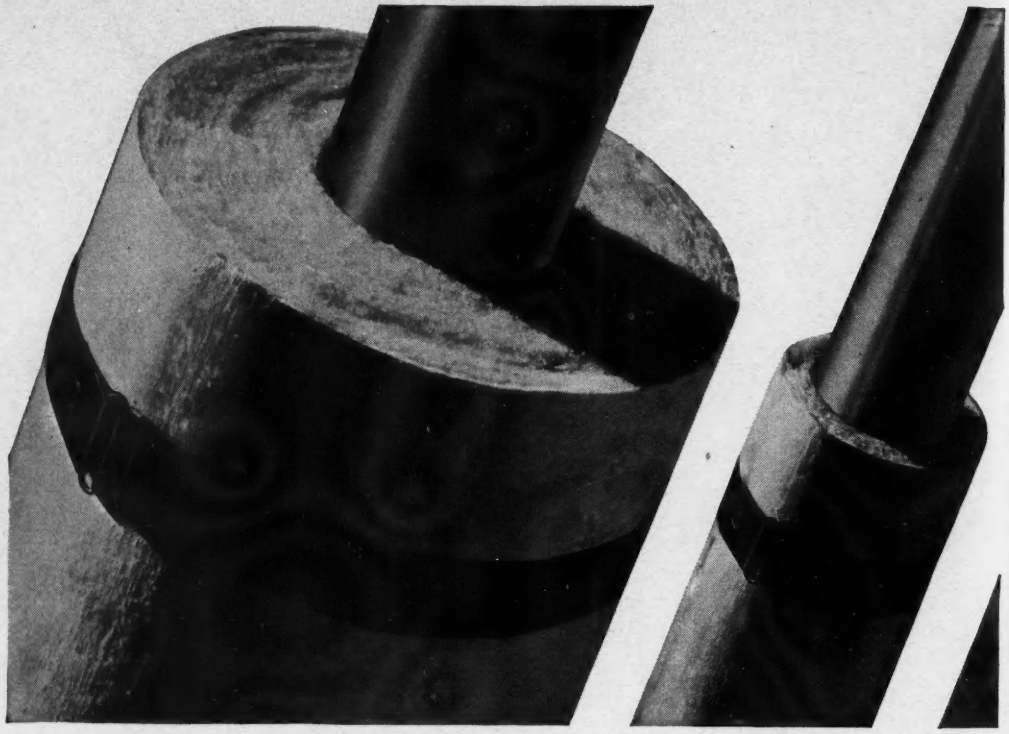
● *VIBRATING WIRE AS SENSING ELEMENT*

A sensing element which appears to be suitable for the measurement of a great variety of physical quantities, such as acceleration, displacement, force, pressure, temperature, torque, etc., consists of a fine wire vibrating in a magnetic field and generating an alternating current of the same frequency as the natural vibrating frequency of the wire. Any slight change in wire tension or length which may result from the action of such physical forces as temperature, pressure, or displacement coupled to the wire will cause a directly measurable change in the output frequency of the unit. When used in an electric band pass filter, discriminator or oscillator, the vibrating wire with its magnet system is included in one arm of a Wheatstone bridge network. When the bridge is used as a band pass filter, it remains balanced for any input frequency other than the resonant frequency of the wire. The energy of the rejected signal is dissipated in the input circuit. When the bridge is unbalanced by an input frequency tuned to the resonant frequency, the energy of the input signal appears in the output circuit. If the bridge circuit is used as a discriminator and the input signal changes in frequency within the limits of the desired portion of the response curve, the output of the network will vary correspondingly. In this way, small changes in the input frequency are converted into corresponding changes in output amplitude. If the bridge circuit is used as an oscillator, feedback and buffer amplifiers are incorporated.

● *SOLDERING GLASS TO METAL*

An American firm of electrical manufacturers announces the discovery of a process by which glass can be soldered to metal, the bond being stronger than the glass itself. The method, which can also be used to solder metal to ceramics and carbon, is currently being tested for industrial application. The glass and metal areas to be soldered are painted with a thin layer of titanium hydride, and solder is placed upon both painted areas. The parts are placed together and then heated under a vacuum. When the temperature reaches about 900° F, the titanium hydride decomposes, causing the solder, which has already become molten, to adhere to the titanium-painted areas of both the glass and the metal. A strong, tight bond is formed upon cooling. By using soft metal solders, it is possible to subject this glass-to-metal seal to rapid temperature changes without danger of cracking; and this despite the wide difference in temperature expansions between glass and metal. This is possible because the differences in movement are absorbed by the solder. The new technique is now in use in aircraft ignition systems, and laboratory investigations have suggested possible applications in the manufacture of transformers, capacitors, and electric motors.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.



Insulation **THICK** and THIN in Fibreglass Rigid Sections

- High thermal efficiency
- Mechanically strong
- Minimum thickness required
- Wall thicknesses from ½″ to 2″
- For pipes of ½″ to 12″ bore
- Easily applied
- Readily available
- Neat in finished appearance

TRADE **FIBREGLASS** MARK

For structural heat and cold insulation. Sound deadening. Acoustic correction. Porous membranes for pipe wrapping, flooring, roofing. Battery separators and air filters. In textile form for electrical insulation and flameproof decorative fabrics.

FIBREGLASS LTD., RAVENHEAD, ST. HELENS, LANCS. (ST. HELENS 4224)

LONDON OFFICE:
63/65 Piccadilly, W.1 (Regent 2115/6)

GLASGOW OFFICE:
136 Renfield St. (Douglas 2687)

NEWCASTLE-ON-TYNE OFFICE:
c/o Pilkington Brothers Ltd., Westgate Rd.
(Newcastle 20938)

THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XII. No. 7 JULY, 1951

Russia's Mineral Potential

MILITARY power stems from industrial power, and industrial power, in turn, depends predominantly upon an ample and assured supply of mineral raw materials. Soviet reports naturally tend to overestimate tonnages and to include geologically inferred ore as measured reserves. Such exaggerations should be expected where the hundreds of prospecting parties are directed to find ore, or else be sent to slave labour camps. Competent geologists, engineers, and metallurgists were liquidated along with other professional men in the purges of the 1930's and a similar fate may await those who might venture to write a pessimistic report. Although, in view of such pressure, Soviet reports often must be discounted, they need not be discredited.

The normal economic yardsticks are too inflexible to employ under the Soviet central management. Provided the recoverable mineral is urgently needed, low grade of the ore, poor accessibility, mining and treatment difficulties or high costs may be no barrier to exploitation. No private company could undertake the vast exploration now in progress in some of the oil fields between the Volga and the Urals where the yield per well is bound to be small. The miserable quality of coal from the Kizel field, the Korkimo brown coal operations, and the meagre returns from innumerable lean gold placers and base metal lode mines further illustrate the contrast between standards in the U.S.S.R. and in the United States.

However sceptical one may feel about the trustworthiness of Soviet geological reporting, it must be recognised that, including satellite countries, the Soviet sphere of influence extends over 13 million sq. miles, which is greater than the area of the entire British Commonwealth and compares with 3·6 million miles possessed by the United States. Enough is known of the geology of this vast area to enable some evaluation of official claims of exploration achievements. As to production claims, the method of presenting statistical statements in percentage changes or percentage fulfilment of an annual production plan is deliberately confusing. With some diligence, however, clues can be found for translating these relatives into absolute figures. Unfortunately, different analysts sometimes come out with different figures, but in regard to coal, iron and steel, and certain other basic commodities, there is wide agreement. Soviet statistics apparently are not deliberately falsified.

Although Russia is still largely an agrarian country, its industrial progress under the several Five Year Plans has been impressive. Comparisons based upon conditions under the Czarist regime show gains that are almost fantastic when expressed in percentages.

Oil supplies are undoubtedly scarce. Russia's output is barely 10 per cent of that of the United States, and the 2 or 3 million additional metric tons that might be squeezed from Balkan satellites is only a drop in the bucket. Seizure of the rich oil fields of Iran and Iraq, however, would double the Soviet supply and so provide enough for the Kremlin's needs for all-out warfare.

Industries are naturally attracted to coal fields. Russia has abundant coal resources and so far she has managed to keep production in step with the rapidly expanding demand. Steel has been called the symbol of Russia's rise to military power. Her iron ore resources are relatively more abundant than even the coal resources, possibly greater than those of any other country. It is true that only 5 per cent of the iron resources lies east of the 63rd Parallel and all but 9 per cent of the coking coal lies West of that line. It is also true that it is a long rail haul for coal from the Kuznetsk Basin to the Ural mills and that the steel mills of Central Russia must transport ores from the Ukraine in the South and bring coking coal from the Vorkuta which lies North of the Arctic Circle. Actually, however, 75 per cent of present-day steelmaking capacity is in two regions, the Eastern Ukraine and the trans-Ural area, where ore, coal, and markets for the products are all favourably disposed geographically.

Historically and currently the Russian people have had less experience than Americans or even Western Europeans in handling mechanical devices and in building and operating industrial plants. Significant, too, is the stifling effect of their industrial system upon the resourcefulness of Soviet engineers. Individual initiative is discouraged below the top levels of command, where decisions are made for political rather than technological or economic reasons, often without intimate knowledge of on-the-spot conditions.

Extract from a cogent analysis of Russian resources by one of America's leading mineral economists, Paul M. Tyler, published in the June issue of "Mining Engineering."

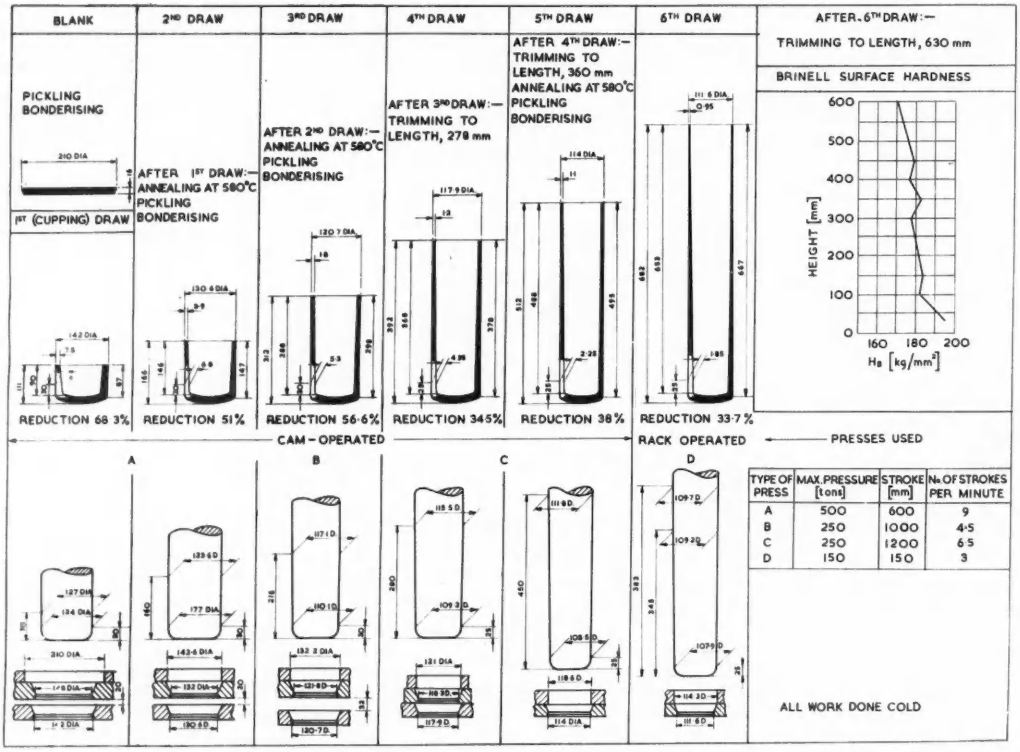
GERMANY

Deep Drawing from Heavy-Gauge Steel Plate

By U. BAUDER. (From *Stahl und Eisen*, Vol. 71, No. 10, May 10, 1951, pp. 500-512, 19 illustrations.)

To determine the optimum deformation (reduction) values in deep-drawing of heavy-gauge steel plate of up to ⅝ in. thickness, conditions in the first (or cupping) draw and the following reducing draws have been experimentally determined, and correlations between the reductions of the base, the wall thickness and the deformation of the cross-section along a shell generatrix have been established. Die-rings of different profiles were investigated and the so-called "tractrix" profile found best suited. Further investigations covered advantages derived from using double or multiple draws, influence of work-hardening on obtainable reduction and on the mechanical strength of the product, as well as means to reduce the drawing load.

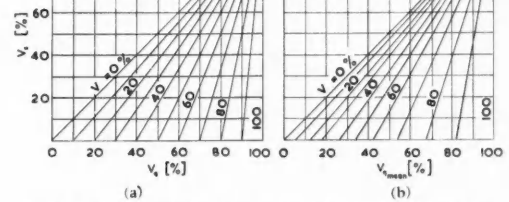
WHILE considerable literature exists on the drawing of light sheet-metal with or without blank-holders, comparatively little has been written about the deep-drawing of cylindrical shapes from heavy-gauge plate. The method is, on the other hand, becoming increasingly popular, in particular, for steel plate, since it enables economical mass production of many current industrial shapes, e.g., cylinders, casings, sleeves, pressure containers, etc., particularly thick-bottomed shapes with relatively thin sides. The process involves two stages, namely, cupping and reducing. The first is effected in a single draw, usually without a blank-holder, from a comparatively thick punched blank, followed by the necessary number of reducing draws to form the wall. Thermal and surface treatments are interposed between the draws as required. The conduct of the process is governed by the cold-working properties of the material, the surface treatment and the means of lubrication used, and the shape of the tools. Ordinary deep-drawing steel plate can be used if the amount of reduction is inconsiderable ; otherwise, a non-ageing steel is required, and good results have been obtained with a mild, aluminium-killed, special steel, which is non-ageing and has the following analysis : 0·07-0·12 per cent C, 0·12 per cent Si max., 0·45 per cent Mn, 0·025 per cent P, 0·03 per cent S, 0·25 per cent Cu and 0·02 per cent Al. Tests have been made with this steel on blanks supplied by the steel-mills in the normalised state with an average grain size not exceeding 0·03 mm dia. and a hardness between 100-115 Brinell, corresponding to a tensile strength of 36-42 kg/mm² (23-26·7 tsi). Notch impact toughness was specified at 15 kgm/cm² along, and 9 kgm/cm² across the direction of rolling (700 and 420 ft lb/sq in.). The deep-drawing of steel has, however, only been made possible by the development of the bonderizing process providing a phosphate coating which, with the aid of a suitable lubricant, acts to prevent sticking in the die and enables production of a smooth, sound surface. The number of draws, amount of draft or deformation used, and tool design, have hitherto been decided by workshop tests or experience. It appears advisable, however, to put



TYPE OF PRESS	MAX. PRESSURE [tons]	STROKE [mm]	No. OF STROKES PER MINUTE
A	500	600	9
B	250	1000	4·5
C	250	1200	6·5
D	150	150	3

Fig. 1. Flow sheet for deep drawing from 16 mm (⅝ in.) steel plate; cupping draws and 5 reducing draws of which 3 are double draws.

these factors on a sound theoretical basis, and a series of experiments was therefore made, using blanks of 210 mm ($8\frac{1}{4}$ in.) diameter and 16 mm ($\frac{5}{8}$ in.) thickness, drawn in six stages with three intermediate anneals, double draws being extensively used. Fig. 1 shows the drawing stages. The investigations extended to conditions in the dishing or cupping operation, the development of the subsequent reducing draws, the influence of both tool form (particularly the blank-holder) and the type of press, and friction in the die. The use of double draws, with two blank-holders in succession, was also specially considered. In regard to the cupping draw, the use of a tapered punch is suggested in view of the fact that the required wall thickness is usually much less than that of the original blank, increasing gradually from the top to the bottom. In the cupping operation, the material is subjected to tangential upsetting forces producing a deformation V_d (reduction of base diameter), when the ring-shaped part of blank is needed for the formation of the cup wall ; to radial upsetting forces, superseding the tangential, which cause the deformation V_s (reduction of wall thickness) ; and to elongation causing the deformation V_q (deformation of cross-section along a shell generatrix). The principal stress is tensile in the direction of the draw, and is a measure of the total deformation. Although the resulting forces can be calculated logarithmically, it will be found more convenient in practice to consider the deformations V_d, V_s and V_q. It is recommended to correlate the cross-section of the displaced material to the original blank cross-section and to plot a graph (Fig. 2), where



Figs. 2a and 2b. **Relationship beteen V_d, V_s, and V_q** (Fig. 2a) **and V_q mean** (Fig. 2b).

these ratios are shown as percentages. The calculations made have been checked by tests on samples and have shown close agreement. These tests included determination of the amount of work-hardening in the cup, which was found to be greatest at the obvious critical point : the transition fillet between the base and the side of the cup. Intermediate annealing has to be carefully controlled, there being a tendency to grain growth in the critical zone at excessive annealing temperatures ; a hardness of 107-115 Brinell should be aimed at. The maximum obtainable deformation (V_q) in the cupping draw is governed by : (1) the material of the blank—the above-mentioned type of deep-drawing steel was found completely satisfactory in the tests ; (2) the dimensions of the blank—in this regard the ratio of blank diameter to thickness is the critical factor ; (3) internal deformation conditions, which can only be determined in drawing tests ; (4) external influences, viz., shape of blank-holder, shape of drawing punch, type of press, rate of drawing, friction which is determined by the surface condition of both the tool and the blank, and by the type of lubricant used. Examining these individually, the influence of the blank-holder or die ring is decisive for the attainable deformation in the draw. The tests, which included recordings of the drawing pressure distribution over the punch stroke or depth of draw,

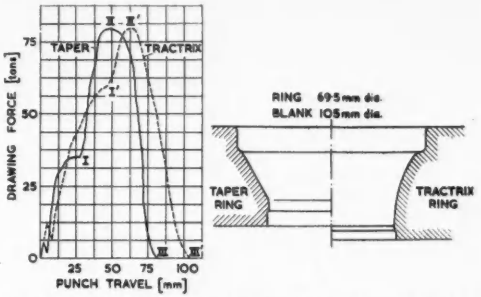


Fig. 3. **Draw diagram of a taper and a "tractrix" ring attaining equal deformation.**

indicated that the so-called "tractrix" die ring (Fig. 3), gives the lowest drawing pressure on the edge of the blank for the greatest degree of deformation. Its disadvantage is its slightly greater depth, involving increased friction, but its lubricating effect is very good because the lubricant is drawn into the gradually tapering gap between the ring and the work, instead of being scraped off by the sharp edge, as in conventional rings. Since the dishing or cupping draw essentially consists of two successive operations, the bending of the blank edge and reduction of the cup wall, it is possible to provide a second ring, which only reduces the wall thickness, thus operating a "double draw" which is frequently used in cupping. The graph in Fig. 3 shows a comparison of the efficiency of a "tractrix" and ordinary taper ring : while the peak pressure is the same, the curve for the "tractrix" ring rises more slowly and steadily and drops abruptly from the peak, with a correspondingly longer deformation path and consequently lighter loading of the material, the tools and the press, giving a smoother and quicker draw, maintaining the bonderized surface intact ; the life of the ring is also increased. The attainable efficiency in the cupping draw was found by these tests to lie in the range of 32-40 per cent. These are reliable limits, which can be maintained in practice. The shape of the drawing punch also influences the attainable deformation. In particular, the fillet or transition at the bottom edge must be of ample radius to prevent tearing ; the minimum radius thus depends on the thickness of the blank and the elongation value of the material. The maximum drawing force P can be evaluated from the formula

$$P = \frac{1}{\eta_{Form}} F_1 \log_e \frac{F_0}{F_1} k_{fm} \quad \text{where}$$

η_{Form} = efficiency of cupping draw (32-40 per cent)
F_1 = cross-sectional area of material in draw gap
F_0 = cross-sectional area to be deformed
k_{fm} = average resistance of material to change of shape—determined by hardness testing of blank and drawn cup, or from graph, Fig. 4, or estimated from experience records.

The type of press likewise influences the drawing efficiency. Some success has been achieved by the use of shock-absorbers in mitigating the impact shock of the punch on the blank. When using crank presses for cupping, mean speeds of 11-15 m/min (36-50 fpm) may be applied ; oil-hydraulic presses used for the same operation show mostly lower output. The final influence affecting the drawing force and consequently the amount of attainable deformation is the friction between the work and the tool. All tool surfaces must be bright-polished ; good cooling and lubrication are essential, and the bonderized coating must be of sufficient thickness for the intended amount of draft, since otherwise it can be scraped off and may cause sticking in the die-ring or blank holder. Drawing

tests which have been carried out show that blank proportions are decisive, the essential factor being the "thickness ratio" of internal cup diameter to blank thickness. This may be up to 25 without using a blank holder ; with a "tractrix" ring, ratios up to 35 or even 44 could still be used. Wrinkles were prevented by annealing the blank after blanking. Above this limiting value, tearing takes place, either at the bottom or at the upper edge ; in the first instance, the cause is overstressing at the transition between the bottom and the side wall of the cup ; in the second case, overstressing in the wall is the cause. Tests made to determine the relationship between the stresses in drawing and the thickness of the blank indicated the following maximum drafts obtainable : at the bottom 66·4 per cent reduction, at the upper edge 69·0 per cent, all other conditions being optimum. Safe working values are : for a thickness ratio of 5 to 7, 50-52 per cent (for both) ; for a thickness ratio of 7 to 10, 48-50 per cent, and for a thickness ratio of 10 to 15, 44-48 per cent. Modern practice tends to the use of double or duplex draws, enabling far higher degrees of deformation (i.e., reduction) to be obtained. Tests made in this direction showed that the ultimate result depends principally on the reduction obtained in the first blank holder ; if that is satisfactory, at least 30 per cent further reduction can be obtained in the second ring. A further test was made with a triple draw and showed 82 per cent reduction of cross-section to be attainable in cupping. In industrial mass production, however, such high drafts cannot be used, since the tools are too sensitive ; the results do show, on the other hand, what is attainable, under suitable conditions, in the way of reduction of area. Further tests on reducing draws showed that a figure of about 50 per cent reduction in cross-sectional area should be easily attainable, provided the drawing tool is properly centred. Hitherto, not more than 40-45 per cent has been attempted, but with a drawing tool (ring, die and punch) of suitable shape and properly polished, reductions up to 52·5 per cent should always be attainable. The angle of taper of the draw should preferably be from 10-15 deg. and should never exceed 20 deg. (at which the attainable reduction, according to the tests, is not more than 41·8 per cent). The bonderized coating should be in perfect condition, and proper cooling and lubrication provided. In the case of small wall thickness, differences in wall thickness and in quality of material are determining factors, and reduction should not be pushed to the upper limit. The ultimate conclusions from the tests are as follows : (1) The degree of reduction actually attainable is of the order of $V_{q\,max} = 58$ per cent under the most favourable conditions. (2) In mass production, the necessary control of working conditions is frequently unattainable, and it is recommended that 50 per cent reduction be not exceeded if tearing is to be avoided. (3) In regular production, particularly if small wall-thicknesses are required, the reduction of area should not exceed 46-48 per cent, which is already more than the figures hitherto used. If the previous draw has already produced some degree of work-hardening and a smooth surface, the resulting draft in the next pass will essentially depend on the amount of work-hardening already acquired.

The cycle of operations following on the cupping draw is then as follows : Annealing, pickling and bonderizing ; 2nd draw, annealing, pickling and bonderizing ; 3rd draw (double), reduction of area $V_q = 56·1$ per cent ; 4th draw, reduction of area 37·6 per cent, trimming ; 5th draw, reduction of area 22 per cent, trimming ; 6th draw, reduction of area 11·8 per cent. Total deformation in 3rd to 6th draws is 81·8 per cent. This did not entirely exhaust the deformation capacity of the material. Thus, to utilize the drawing power completely, a further pass with less draft could still be interposed. The experimental results show that reduction in successive draws without intermediate annealing can be pushed to a total value of 82 per cent in ordinary production. The limit is set not only by the drawing properties of the material, but also by the characteristics of the bonderizing material. In production, it is advisable to perform the reduction stepwise, decreasing in successive stages. Further experiments with double draws indicate the upper limit of deformation to be about 65 per cent. This is already very nearly the value obtained in extrusion. In actual production, maximum values of 50-60 per cent can be assumed ; double drafts with these values have proved satisfactory. The operating limit, using double draws in series, can be estimated at 82 per cent total deformation. Comparing these reductions with those currently attainable in other shaping processes, it will be found that in tube drawing, using killed mild steel, reductions up to 56·6 per cent are obtained—i.e., well within the limits attainable in deep-drawing.

Investigations in regard to deformation efficiency η_{Form}, considering all factors, show that there is a difference between (1) drawing of material process-annealed and bonderized and (2) drawing of equally treated material which has undergone preliminary draw operations. With a drawing speed of 12 m/min (40 fpm), well polished drawing tools and soapsud lubrication, the following results are obtained : (a) In previously drawn samples with a smooth surface, the deformation efficiency is usually higher than for annealed and bonderized samples ; (b) the efficiency is always higher for reduction of the wall than at the point where the pressure is at its maximum ; (c) the efficiency improves with decreasing taper of the tool ; (d) the quality of the surface of the ring or blank holder is particularly important ; the value is less in a new ring, until toolmarks have been eliminated. Tests show the following values for efficiency, i.e., the maximum attainable and the practical optimum, respectively : (1) Annealed and bonderized ; 40 per cent and 34 per cent for the peak of the force-way curve, 55 per cent and 52 per cent for the wall. (2) Initial draft 20 per cent, surface smoothed : 55 per cent and 52 per cent for the peak, 72 per cent and 70 per cent for the wall. The first are the best attainable values ; the second, those which can be maintained in industrial production under otherwise optimum conditions. The relationship between work-hardening and degree of deformation is of particular importance for mass production. A great number of tests to determine the relationship between progressive deformation and tensile strength has enabled plotting of a "work-hardening curve" (see Fig. 4) ; the scatter of the experimental points has been considered by plotting upper and lower limit curves, a mean curve passing through the most frequently recorded values. The scatter is due to the inevitable inaccuracy of hardness measurement by the Brinell test, inaccuracies in determining the degree of deformation, and variations in the material constants. Such scatter is inevitable in work-hardening measurements. Examinations of such curves of drawing forces immediately shows an exceptionally high value for the

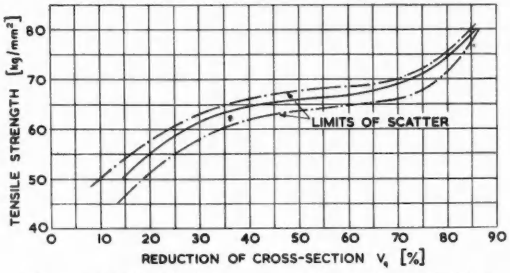


Fig. 4. **Relationship between work-hardening and deformation of cross-section in the drawing of deep-drawing steel.**

peak forces, sometimes as much as four times the value for the forces needed for the drawing of the wall. This is an exceedingly disadvantageous circumstance and frequently determines the limit of possible deformation in the draw. The peak pressure arises when the bottom of the blank passes through the die ring or blank holder, the process in that stage being more in the nature of extrusion than drawing.

The drawing angle is of similar importance, mainly at the peak : with a 10-deg. angle, draws of up to 52·5 per cent were obtained without difficulty, while with a 20-deg. angle, tearing took place. Angles as small as 6-8 deg. have already been used, but with the disadvantage of bulging at the bottom and greatly increased friction. The influence of drawing speed on drawing pressure has not yet been completely elucidated, but it would appear that at very low speeds (0·1 fpm), the pressures rise very considerably, particularly at the peak. A study of the deformations attainable by double or multiple drawing shows, in particular, that interruption of the process of deformation corresponding to conditions in the reducing draw has the effect of impeding further deformation, while gradual and continuous drawing aids the process. Hence, in multi-stage drawing, the draws should follow each other as quickly as possible. In this regard, double or multiple draws are particularly advantageous since the work is shaped in a single stage, and possibly even simultaneously, by passing through two or more die rings. Furthermore, the work becomes increasingly heated by passing through the successive rings, which counteracts the effect of progressive work-hardening. The bonderized coating becomes smoothed in the first ring pass, thus affording better lubrication conditions and consequently higher efficiency in the subsequent pass or passes. The pressure curve of a double or multiple draw shows two or more pressure peaks, corresponding to the passage of the piece through the successive die rings or blank holders. For best efficiency, these two peaks should be as far apart as possible, to prevent the risk of the pressure building up to a higher value than in a single draw. The ideal curve is nearly trapezoidal with an easy pressure rise and constant drawing pressure. This is more easily attained with a double draw. The reduction attainable in a double draw is of the order of 55-58 per cent, so that in two such draws in succession, without intermediate annealing, a total reduction of 82 per cent can be obtained. Tests made with triple draws showed that for properly annealed and bonderized material, a reduction of 70 per cent in a single pass was still attainable.

U.S.A.

Metal Spinning

By D. REEBEL. (From *Steel*, Vol. 128, No. 23, June 4, 1951, pp. 88-91, 114, 11 illustrations.)

This fabrication method should be seriously considered, whether a problem is simple or intricate, a highly specialised single project or a mass production operation. Outstanding economies are being realised by the use of newly designed automatic spinning lathes which easily handle stainless steels heretofore considered to be non-formable.

INVESTIGATION of metal spinning potentialities—regardless of the metal or alloy used—may offer lowered production costs in addition to materially stepping up output. A wide variety of products is to-day being economically produced by this method, which eliminates the need for costly metal-working tools and dies. A simple wood or steel form—turned to the shape of the finished product—is usually all that is needed for a durable, long-lasting spinning block. If, at a later date, product design changes require block revision, these can be effected economically. This flexibility should not be overlooked when comparing relative costs of spinning and other fabrication methods. Heretofore, production runs of 5000 or more pieces were not considered for spinning. However, by using mechanical and automatic spinning lathes, such runs to-day must be individually studied before definite conclusions can be reached regarding the economics of spinning the product.

Automatic spinning lathes operated by push-button control can be used for many different parts in any quantity from a few pieces to over a million. The automatic spinning unit has a cycle similar to that of a full battery of drawing presses. A blank is placed on the lathe by the operator, a button pushed, and the finished spinning emerges ; the equivalent of six to eight operations are automatically performed in a few seconds.

Basically, all metal spinnings are produced as follows : A wood or metal form is turned to the exact shape and dimensions desired in the final spinning. The metal blank is clamped into position in front of the form. Both revolve at speeds varying from 50 to 2400 rpm. Lower speeds are used for thick and large sections where the heaviest spinning pressures are used, while the higher speeds are indicated for thin small sections. Different adhesive lubricants such as soaps, greases, beeswax, powdered graphite in CCl_4, etc., depending on the material being spun, are applied to the blank to cut down friction. The edge of the revolving blank is frequently bent back approximately $\frac{1}{4}$ to $\frac{1}{2}$ inch to ensure rigidity and prevent the metal from buckling during spinning. The workman next exerts proper pressures on the disk with a long blunt tool, which causes the metal to flow snugly over the form. Final finishing operations can include trimming, beading or flanging. Thick gauges, hard metals, and large-diameter disks are worked with a roller or lever-type tool. Shape, size, gauge and temper determine the number of breakdown operations required to produce the desired finished shape. Fig. 1 shows the various breakdown blocks needed to produce a typical spun shape.

The easiest and most economical form to shape by spinning is the cone. Even when the material is worked down to its extreme depth, straining is not too severe. More difficult to spin is the hemisphere. As can be noted in Fig. 2, angles grow increasingly sharper as the material is spun down. The hardest shape to produce

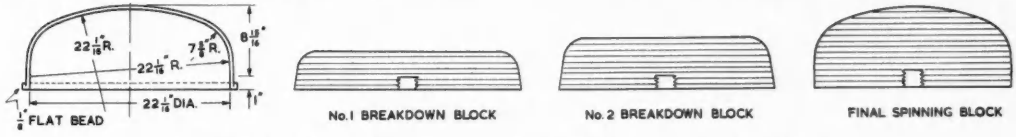


Fig. 1. **Detail of finished-spun part and the spinning blocks required to produce it.**

is a straight-sided cylinder. Sharper angles encountered during the spin-down put the metal under greater strain ; more time and greater operator skill are needed to hold accurate tolerances in the finished product. If sharp angles can be eliminated in a spun product,

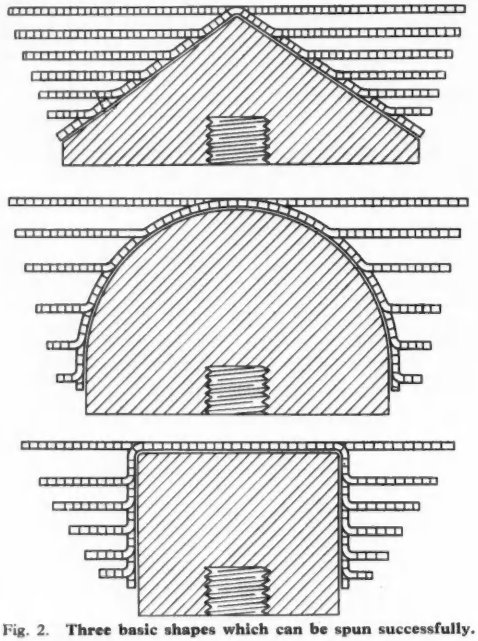


Fig. 2. **Three basic shapes which can be spun successfully.**

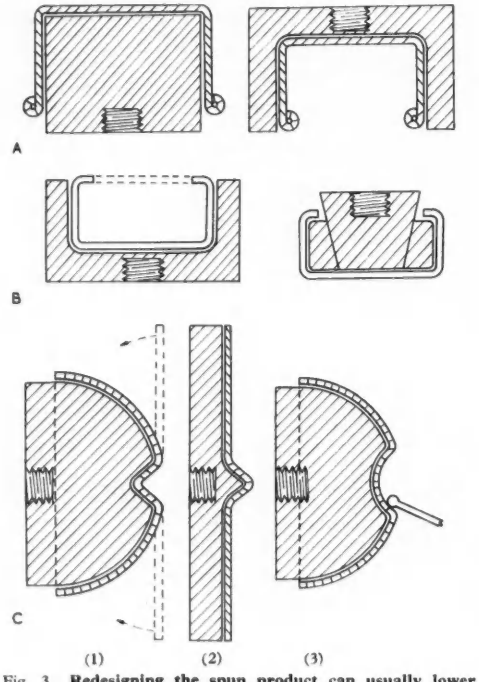


Fig. 3. **Redesigning the spun product can usually lower production costs.**

valuable production time will be saved.

Shape, size and metal gauge must all be considered when spinning is contemplated as a production method. All factors are interrelated : Shape depends on size and metal gauge ; size on shape and gauge requirements ; and gauge on shape and size. Tolerances desired and quantities involved have an important bearing on whether a product can be most economically produced by spinning or other methods. A shape must be generally concentric or round to be produced by the spinning technique. It can be a straight cylinder having the same diameter throughout, or it can be a hemisphere, cone, partial circle or any segment of a circle. Concentric details can also be spun into any part of either a square or rectangular sheet. Diameters of spinning can be projected from $\frac{1}{4}$ in. to 12 ft. Almost all types of sheet metal can be spun.

As a rule, simple shapes can be spun in thicknesses up to $\frac{1}{4}$ in. for soft metals, about $\frac{3}{16}$ in. for low carbon steels and about $\frac{1}{8}$ in. for stainless steel. Standard limits for maximum spinning economy are $\pm \frac{1}{8}$ in. for diameters beyond 36 in., $\pm \frac{1}{16}$ in. for medium sizes which range from 18 to 36 in., $\pm \frac{1}{32}$ in. for diameters under 18 in. Tolerance limits of a few thousandths of an inch can be spun ; however, this greatly increases costs. Often, spinning costs can be materially reduced by various design changes which take into consideration the operations involved. Very often, these simple modifications produce improved product appearance and increase the structural strength of the metal. Certain manufacturers' case histories are detailed in Fig. 3 to show some constructive suggestions which realised worthwhile cost savings in the spinning operation.

On part A, an outside bead can be added with a standard beading tool, while on the original block an inside bead requires another block to prevent bellying of cylinder edges during beading. This extra operation increases cost. An extra hollow block is required to form the inside flange on part B. If liberal depth and diameter tolerances are allowed, this method is adequate, otherwise an expensive collapsible block must be used for the flanging job. Part C, a hemispherical mixing bowl, was originally designed with a sharp indentation (1) at the base which required an extra block (2) and spinning operation. Changing to a larger radius on the indentation allowed a " push-in " operation (3) on the same block and set-up used for spinning the bowl. This resulted in a sturdier, more sanitary, product that could be produced faster and cheaper.

On parts involving complex design, such as narrow throats and other variations in the diameter of the product, hollow collapsible blocks or internal rolls are required. Certain shapes can be produced only on the blocks, while others can be spun by either method. Where quantities permit, off-centre type internal roller devices are frequently used, which eliminate handling (block assembly and disassembly). This offers much greater production economy.

The hot spinning technique is used for heavy-gauge work in many metals, especially magnesium. An oxy-acetylene flame imparts a degree of ductility to the metal which is wholly lacking when it is in the " cold " state. The flame plays on one side of the revolving spinning, while the work tool is operated on the other side.

Spinning is also applicable to metals other than those where the surfaces are solid and unbroken. Special techniques to-day make it practical and economical to spin shapes of perforated and expanded metal. The holes or mesh are elongated according to the contour changes of the material. However, these distortions are usually without any significance for the end use of the product. An outstanding example is a parabolic antenna which was recently spun from a blank of two welded half-circles of flattened, expanded metal 102 inches in diameter.

On the Use of Torsion Bars in Guillotine Shears

By A. LIGIER. (From *La Métallurgie*, Vol. 83, No. 4, April 1951, pp. 267-269, 6 illustrations.)

A particularly interesting application of torsion bars is described, with reference to their use in guillotine shears, for compensating the weight of the shear-blade carrier and taking up any play or backlash in the gears. The torsion bar, as the most perfect form of torsion spring member, is particularly suitable for this purpose and has the further advantage of easy standardisation and manufacture.

THE torsion bar, as the most simple form of torsion spring, presents particular interest as a mechanical element in the construction of machine tools. This article will deal with the particular case of guillotine shears, in which high operating speeds are associated with high inertia of the moving parts, great range of displacement, and high frequency of the alternating load. This is really both an extension and intensification of the conditions already applying in mechanically-propelled vehicles, for which torsion springs and their simpler form, the torsion bar, have already been freely used. A theoretical analysis immediately shows that the simple torsion bar of full, cylindrical cross-section, is far more efficient than any other form of spring, having regard to the more favourable distribution of the material and the absence of losses due to friction of the spring laminations. In the particular case mentioned, the convenience of being able to calculate the design to closer limits as well as the convenience of manufacture of the simple bars, which furthermore admit of extensive standardisation, have proved decisive for the application of torsion bars in the construction of high-duty guillotine shears intended for mass production. Thus, the GRIMAR guillotine uses cylindrical torsion bars for balancing the upper shear-blade carrier, and automatically taking up any slack or backlash in the transmission. With a particular view to mass production of these torsion bars, with consequent considerable saving in cost, these have been designed as standard forms of conventional design, their number being varied in accordance with the load to be dealt with, i.e., according to the type or size of machine tool envisaged. In principle, the assembly of these torsion bars is effected by gripping each bar at one end and connecting it with a crank lever, to the end of which the load is applied. In the assembly shown in Fig. 1, there is an initial angular deflection of the bars and a further " working angle " of deflection on application of the load. Since guillotine shears have in any case a certain travel or stroke, this arrangement ensures a certain operational flexibility and reduces the necessary travel or deflection of the torsion bars themselves to a minimum. The combined angle is of the order of 45 deg., for a rate of about 60 strokes per minute. The torsion bars are assembled in the machine in such manner as to be exposed to torsional loads only, all secondary effects being eliminated or reduced to a minimum. As a matter of interest, the material used for the bars is a tempered and drawn steel with an ultimate strength of 150 kg/mm², and an elastic limit of 140 kg, containing 0·42 per cent C, 0·70 per cent Cr, 1·5 per cent Si, 0·25 per cent Mo, and 0·60 per cent Mn. It is recognised that any steel can be made to work very satisfactorily in the vicinity of the ultimate strength if suitable cold-working pre-treatment is applied. Consequently, the design and arrangement of these torsion bars has been specially adapted for convenience in surface cold-working, such as prestressing by shot peening. Hence, it has been possible to reduce very considerably the weight of material employed, a fact which favourably influences the cost of such torsion bars as compared with that of springs of conventional design. The possible inconvenience of the greater length of the bars has been compensated by arranging them at the back of the machine frame, where they are readily accessible for inspection or replacement. In conclusion, it may be mentioned that the securing of the torsion bars in their holders is also effected by a novel method, i.e., by the provision of splines at the gripping point, following an already acknowledged technique and method. This arrangement ensures an equable distribution of the forces in the bar, without unduly increasing the necessary dimensions. Care should be taken, however, that the transition from the splined to the plain, and thinner, section of the bar

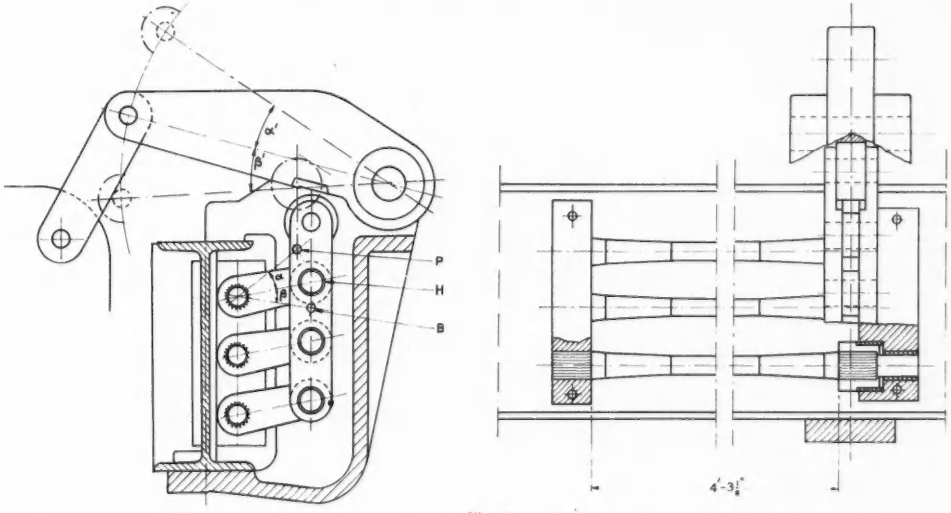


Fig. 1.

P — initial position of lever ; *H* — top of stroke ; *B* — bottom of stroke ; α — angle of initial tension ; β — working angle.

should be as smooth as possible, to obviate stress-concentrations. This example consequently shows that the problem of the application of the torsion bar as an element in mechanisms other than vehicle suspensions, where it has hitherto been commonly used in the capacity of a spring or elastic member, is quite capable of effective solution. The use of this element in guillotine shears, as described above, has proved completely satisfactory, not only in regard to ease of manufacture and assembly, but also because of better utilisation of the qualities of the material employed and the greater operational flexibility.

RUSSIA

On the Mechanism of Disruption of High-Alloyed Steels During Forging

By M. V. RASTEGAEV. (From *Izvestiya Akademii Nauk*, No. 8, August, 1950, pp. 1183-1188. 9 illustrations.)

A NUMBER of high-alloyed steels have a relatively low plasticity. The aim of the research work reported here was to determine the reason for disruption of such high-alloyed steels during shaping under pressure and to investigate their plasticity. The results given here were obtained for a particularly brittle high-alloyed steel.

A specimen of 35 mm dia., made of a typical cast steel, was forged by a flat-surface hammer and in dies at various temperatures ; the steel remained brittle in every case. The first blows of the hammer produced a " stone-type " fracture whilst at higher temperatures the fracture was " needle-shaped " similar to a dendritic structure. These two types of fractures show that the character of the disruption depends on the intermediary layers which form at the points where disruption takes place.

To determine the character, distribution, and temperature limits of the formation of such intermediary layers, a number of specimens were subjected to differential heating. Strips of 2 × 6 × 130 mm were cut longitudinally from appropriate ingots. The specimen was placed in a procelain tube of 8 mm dia., which was then put into a hot furnace heated by silite rods and so placed that one end of the specimen was outside the furnace whilst its other end was in the zone of maximum temperature of the furnace. The furnace was kept at a constant temperature during the experiment and the temperatures at the individual parts of the specimen were measured by thermo-couples. The heated specimen was removed from the porcelain tube and quenched in cold water. The specimen was then longitudinally ground, polished, and etched. The structure was investigated throughout the entire length of the etched surface at magnifications between × 33 and × 1000, the temperatures attained by the individual parts of the specimen during heating ranging between 400 and 1270° C.

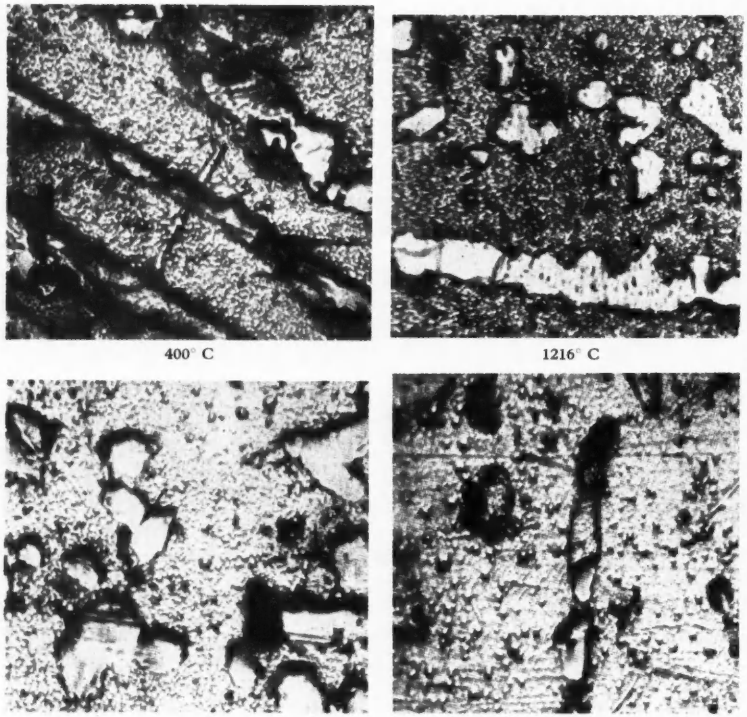
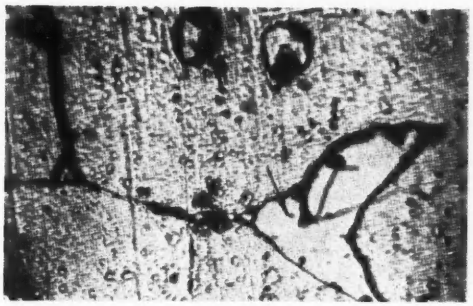


Fig. 1. **Parts of a continuous photograph of the microstructure of a high-alloyed steel, differently heated to temperatures between 400° C (at one end of the specimen) and 1270° C (at its other end), and subsequently quenched in cold water. Magnification × 1000.**

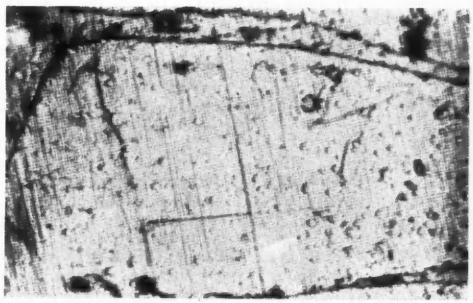
Photo-micrographs obtained at a magnification of × 1000 are shown in Fig. 1. It can be seen from these that the dendritic structure (photo-micrograph for 400° C) is maintained up to a temperature of 1220° C, and at this temperature light-coloured flakes are formed which have a microhardness of 280 to 285 H_B (see Fig. 1, photo-micrograph for 1221° C). At higher temperatures, these flakes begin to dissolve and to form chain-like links and films (Fig. 1, photo-micrographs for 1231° C and 1239° C), the hardness of these flakes increasing to 425 H_B and, in some cases, even to 700 H_B. Finally, the separate flake films unite to surround the grains (photo-micrographs for 1256° C and 1267° C) and to form a continuous grid. Their microhardness is 300 to 400 H_B, whilst that of the grains is 160 to 220 H_B.

At temperatures above 1270° C, a " needle-shaped " fracture will form.

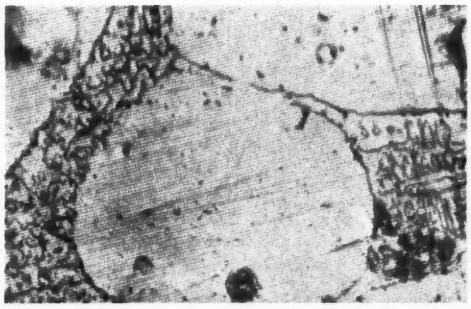
At temperatures between 1216 and 1256° C, the lighter-



1239° C



1256° C



1267° C

Fig. 1 (continued.) **Magnification × 1000 × 0·85.**

coloured flakes lose their firm adherence to the base material ; if the specimens are not prepared very carefully, such flakes may break out and the photomicrograph will show dark patches at the affected spots (Fig. 1, 1216, 1221, 1231, 1239 and 1256° C). The disrupted continuity between the flakes and the base material at these temperatures appears to be the reason for the occurrence of a stone-like fracture during deformation at lower temperatures.

The shape of the surface changes during the forming process. The layer $a_0 - b_0 - a_0$, Fig. 2, will be displaced by shaping to $a - b - a$. Depending on the temperature occurring during shaping in the individual parts of the specimen, changes in structure will occur similar to those which take place in the case of differential heating of specimens.

This assumption was confirmed experimentally on a number of high-alloyed steels. Cylindrical specimens of 21 mm dia. and height, cut from an ingot, were

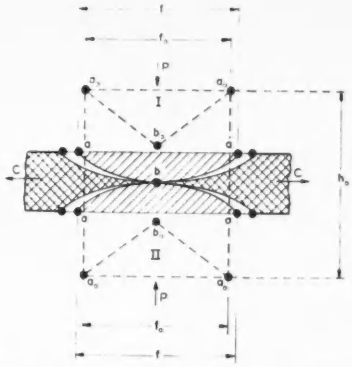


Fig. 2. **Schematic representation of a crack during forging of a cyclindrical specimen with a flat surface hammer.**

shaped in a die ; the results obtained are summarised in Table I.

TABLE I. EXPERIMENTAL RESULTS OBTAINED BY FORGING CYLINDRICAL SPECIMENS WITH BLOWS OF A 90-KG HAMMER FALLING FROM VARIOUS HEIGHTS, AT VARIOUS SPECIMEN TEMPERATURES.

Number of specimen	Testing temperature °C	Deformation %	Observations on results obtained
3–1	1220	55	Specimen became disrupted.
3–2	1170	36·4	Cracks occurred on the lateral surfaces by flaking off.
3–3	1100	27·0	One crack, by flaking off, occurred on the lateral surface of the specimen.
3–4	1000	36·0	Clearly noticeable cracks, due to flaking-off, occurred on the lateral surface of the specimen.
3–5	1170	17·9	A crack occurred on the lateral surface of the specimen.
3–6	1100	15·0	No cracks.

Fig. 3 shows the cracks which occurred in the side walls of a few specimens. Cracks occurred in specimens with a deformation below 15 per cent. At higher deformations (55 per cent) carried out at higher temperatures (1220° C), the specimen was badly disrupted and the material displaced in the direction indicated by the arrows C — C of Fig. 2 (see also Fig. 3, specimen 3-1). Crack formation begins at the points *a* (Fig. 2), and microanalysis has fully confirmed the above-mentioned assumptions as to the structural changes.

The results of these experiments appear to indicate that the disruption of brittle high-alloyed steels during deformation is due to phase changes of individual layers of the metal. The question of a general weakening of the material remains unanswered. Fig. 2 shows a schematic representation of the disruption of the specimen 3-1 (Fig. 3), which was heated to 1220° C and deformed 55 per cent by flat hammers.

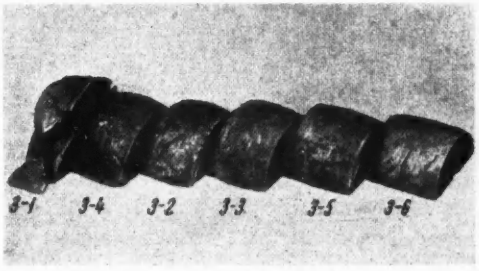


Fig. 3. **Photograph showing the cracks in specimens of a brittle alloy (steel) depending on the degree of deformation by forging with a flat-surface hammer.** (See Table I.).

Scale formation starts at the contact surfaces of the specimens (f_0 in Fig. 2, 21 mm dia.), and during the shaping process the oxidised layer is displaced. Overheating of the layer $a - b - a$ must also be taken into consideration. The temperature of this area exceeds 1220° C and therefore a change in the structure will begin to take place (interconnection of the flake structure), and the continuity will be disrupted between the material spreading in the direction perpendicular to the direction of the applied pressure and the remaining material in the deformation zone. The material forced out by pressure begins to slide freely along the weakened zone, and an overheated, scale-free, fresh part of the metal will move to the surface. Thus, cracks will form the depth of which will depend on the total weakening of the material.

Experiments were also carried out with specimens made of Y-8 carbon steel (0·75-0·85 per cent C, 0·40 per cent manganese, 0·35 per cent max. Si, 0·20 per cent max. Cr, 0·25 per cent max. Ni, 0·04 per cent max. S,

(*Concluded on page* 235)

NORWAY

Further Improvements of Known Methods of Fault Location

By S. E. NIELSEN. (From *Elektroteknisk Tidsskrift*, Vol. 64, No. 2, January 15, 1951, pp. 24-27, 3 illustrations.)

This article describes various procedures by means of which it is possible to determine the condition of a cable at a defective position and to locate short-circuits in multi-phase cables as well as earth faults in heavy cables of short length.

WHEN an earth fault or short-circuit occurs in a single- or multiple-conductor cable, the short-circuit current is frequently sufficient to melt a portion of the conductor at the fault position, leaving it with a considerably reduced cross-section. In certain cases, the length of cable with a reduced cross-section may be equal to several metres of fresh cable, with the result that fault location measurements have to be carried out on a cable of unknown length. The measurements may then indicate a fault at an appreciable distance from the real position. Finally, cases may occur in which the cable is completely burnt through ; in such cases, it is impossible to determine the defective position accurately with ordinary measuring equipment. The standard measuring instruments will indicate the full length of the cable in both cases and will not, therefore, give useful results.

In the course of investigations with a slide-wire bridge, the author evolved a method of fault location which can be of value under special conditions. Although, strictly speaking, it may be regarded as a variant of Varley's method, adapted to the slide-wire bridge, details of this method have not been published previously. It is first necessary to give a brief description of the Murray circuit which is justly popular among fault-location specialists. This will then be followed by a description of the new procedure.

The Murray circuit is shown in Fig. 1. The slide wire S_1 S_2 of total length A is subdivided into two portions by a sliding contact at a. The defective conductor K_1e and the undamaged conductor K_2e in the cable have a length L, so that the total length to be measured is $2L$. Let x denote the distance from K_1 to the fault position. At the near end, the cable is connected to the measuring bridge, while the conductors are assumed to be short-circuited at the far end by a conductor e of extremely low resistance. The two conductors are connected at the measuring station to the galvanometer and the bridge terminals by means of the leads K_1 S_1, K_2 S_2, K_1 G_1 and K_2 G_2. The bridge lead resistances may be neglected in practice, provided the leads are of ample cross-section. The instrument leads have a resistance which should be added to the internal resistance of the galvanometer, but which causes only an insignificant reduction in the sensitivity of the instrument. A milliameter is included in the battery circuit in order to check the measurement current, which must be kept as low as possible to obtain accurate measurements. During measurements, it is occasionally found that a fault with a high transition resistance may suddenly break through ; to avoid any damage to the galvanometer and the bridge, a quick-acting instrument fuses is, therefore, arranged in the battery circuit.

The slide contact is moved to a position a for which the galvanometer shows a zero current. Then, provided that the cable cross-section is constant over the entire length being measured, we have :

$$a/A = x/(2L) \text{ or } x = 2La/A \quad .. \quad .. \quad (1)$$

CHECK OF CABLE CONDITION AT THE DEFECTIVE POSITION

The circuit arrangement of Fig. 2 makes use of the known fact that a length of cable of 1 metre having a cross-section of 1 mm² has the same resistance as a cable q metres long with a cross-section of q mm².

Connected between K_1 and G_1 is an accurately measured conductor with a length equal to 3 metres and a cross-section of 1·5 mm². Its resistance is, therefore, equivalent to that of a length of $2q$ metres of the cable of cross-section q being investigated. Obviously, the reference cable can have any cross-section, provided that the ratio of its length in metres to its cross-section in mm² is equal to 2.

By giving the reference cable an equivalent length corresponding to $2q$ metres of the cable section being investigated, it is possible to take readings over considerable lengths of cable, as long as the bridge accuracy remains satisfactory. The instrument lead G_1 S_1 which is added to the measured cable has no practical effect on accuracy. The battery is connected between the slide contact and K_1, the remaining connections being the same as when using Murray's method. When the galvanometer indicates a zero current, the slide contact being at a corresponding position a, we have the relation

$$a/A = 2q/[2q + 2L] = q/(q + L) \quad .. \quad (2)$$

so that

$$L = q/[(a/A) - 1] \quad .. \quad .. \quad .. \quad (3)$$

The value of L thus obtained should agree with the true length of the cable being measured. If it is appreciably greater, this indicates that there is a cable portion with a considerably reduced cross-section, or possibly a fracture, at the fault position. If L is considerably less than the true length, this indicates the presence of several separate earth faults with very small transition resistances.

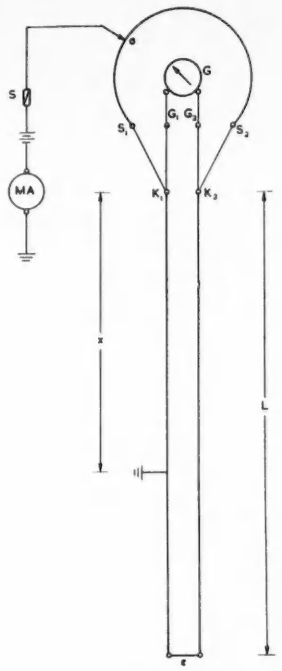


Fig. 1. **The Murray Circuit.**

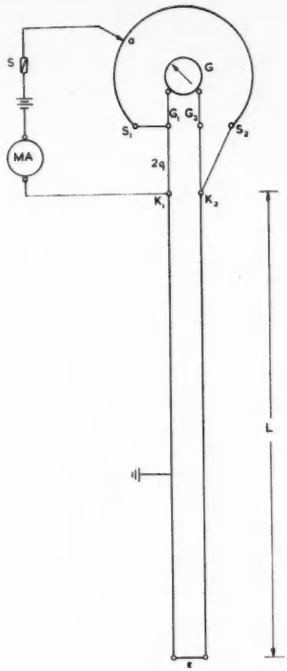


Fig. 2. **Circuit with calibrated cable of equivalent length 2q.**

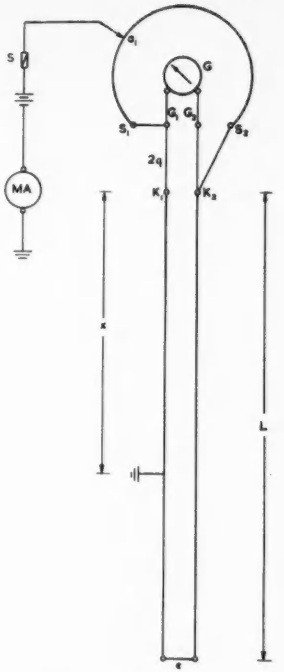


Fig. 3. **Circuit for locating earth faults on short cables of large cross-section.**

ADJUSTMENT OF THE REFERENCE CABLE

The reference cable must be calibrated against a cable of accurately known length and cross-section, taken, for instance, from a new cable drum, with the same type of cable as that which is to be tested. The connections are the same as previously. Equation (3) can be re-written as

$$q = La/(A - a) \quad .. \quad .. \quad (4)$$

The cross-section determined by means of this equation should be identical with the real cross-section. If the value obtained for q is too large, the reference cable is too long and should be correspondingly reduced. If q is too small, the reference cable is too short and should be replaced by another cable of sufficient length.

FAULT LOCATION WITH SHORT CIRCUITS IN ALL PHASES

The best method for locating a fault of this type is, without doubt, Heinzelmann's method, which requires two auxiliary lines, one having a large and the other a relatively small cross-section.

However, if the defective cable is long or if it is situated in a section with heavy traffic, it may be difficult to use auxiliary lines. A solution, in such a case, is to make connections as shown in Fig. 2 and measure from both ends. Let x and y denote the distances of the fault position to the ends of the cable. The measurement at the near end gives $L_1 = x$ and at the far end $L_2 = y$. Then, as a check, the sum $L_1 + L_2$ should be equal to the cable length. This will be the case, allowing for a normal amount of inaccuracy, if the short-circuit is metallic. If it is a transition resistance between the phases, this can be taken as being equivalent to a certain length L_0 of cable of the cross-section considered. Measuring on a given pair of phases a length a from one end and a length b from the other, we obtain

$$a/A = 2q/(2q + 2x + L_0) \text{ and}$$
$$b/A = 2q/(2q + 2x + L_0) \quad .. \quad .. \quad (5)$$

so that

$$x + (L_0/2) = q\,[(A/a) - 1] \text{ and}$$
$$y + (L_0/2) = q\,[(A/b) - 1] \quad .. \quad .. \quad (6)$$

Therefore,

$$L_0 = q\,[(A/a) + (A/b) - 2] - (x + y)$$
$$= q\,[(A/a) + (A/b) - 2] - L \quad .. \quad (7)$$

Since L is known from charts, from previous data or from markings, x and y can be determined by means of eqs. (5) and (6). The practicability of the measurements depends on L_0 being of the same order of magnitude as L, and on its having a constant value throughout the measurements. In the case of multiple-conductor cables, the check tests should be made on each pair of conductors, employing both this method and the one described in the previous section.

EARTH FAULT LOCATION ON SHORT CABLES OF LARGE CROSS-SECTION

If the resistance of the measurement circuit is so small that it is less than the lowest resistance setting of the galvanometer, the galvanometer needle will creep instead of swinging out normally and accurate readings will be very difficult or even impossible to obtain. In such cases it is necessary to increase the cable length artificially, despite the increased inaccuracy, which is, moreover, only of relative importance where short cables are considered. The fact is that an incorrect indication of, say 2 metres, requires the same amount of excavating whether the measured length is 100 or 1000 metres.

It will be an advantage in this case to use the circuit arrangement of Fig. 2 with the reference cable adjusted to an equivalent length $2q$. Measurements are first taken as required by the circuit of Fig. 2, in order to obtain readings for the section of length a. The battery lead is then removed from K_1 and connected to earth as shown in Fig. 3. With the sliding contact at a position a_1, corresponding to a zero current reading of the galvanometer, we have the relation

$$a_1/A = (2q + x)/(2q + 2L)$$
$$= (2q + x)/2\,(q + L) \quad .. \quad .. \quad (7)$$

The first measurement gave

$$a/A = a/(q + L) \quad .. \quad .. \quad (2)$$

Dividing eq. (7) by eq. (2), we obtain

$$a_1/a = (2q + x)/(2q)$$

or

$$x = 2q\,[(a_1/a) - 1] \quad .. \quad .. \quad (8)$$

As already stated, this method is primarily applicable in cases of faults with low cable resistances. If the cable resistance is greater than the limiting resistance of the galvanometer, Murray's method is to be preferred. Finally, it should be borne in mind that the reference cable must be adjusted for each type of cable considered, since the specific resistance of a cable can vary according to type and manufacture. Another point worth mentioning is that once the equipment has been set up for tests according to Fig. 2, it is easy to take further measurements at the same time according to the modified arrangement of Fig. 3. This gives a double check on the measurement accuracy and indicates any possible errors.

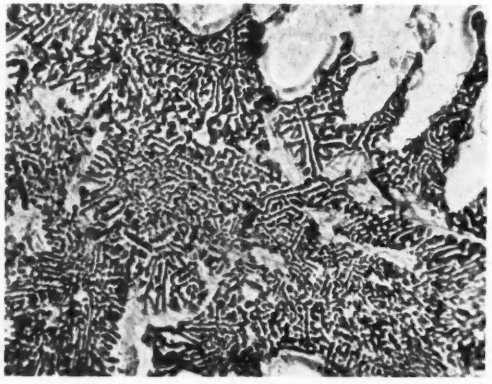
FRANCE

A New Electrolytic Polishing Method for Metallographic Investigations of Si-Rich Light Alloys

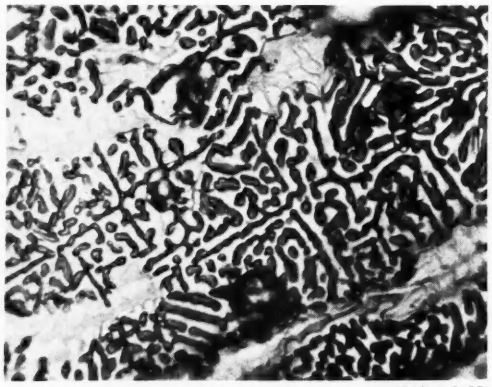
By E. KNUTH-WINTERFELDT. (From *Revue de l'Aluminium*, Vol. 28, No. 175, March 1951, pp. 84-86, 6 illustrations.)

PRESENT methods of specimen preparation for the metallography of Si-rich light alloys are often unsatisfactory, either because structural details are affected by corrosion or because consecutive tests fail to reproduce similar results. The method described below is entirely satisfactory in producing micrographs for visual examination, and even photographic results are superior to those of previous methods, although a certain relief effect limits good definition at high magnifications. An automatic Disa-Electropol machine modified to allow of current reversal is used with an electrolyte of the following composition : 600 cc. methyl alcohol, 400 cc. butyl-cellosolve (ethylene glycol monobutylether), 100 cc. concentrated hydrochloric acid, and 2 cc. "Dr. Vogels Sparbeize," an inhibitor manufactured by Dujardin in Duesseldorf, Germany. The butyl-cellosolve is essential to this composition and cannot be replaced by, say, glycerin.

The specimens are first prepared with emery paper No. 0 to 000. The terminal voltage of the bath is adjusted to 30 volts for a polishing surface of about 0·3 to 0·4 cm². A good micrograph for visual examination is then obtained by polishing for 28 seconds followed by current reversal for 2 seconds. A repetition of this cycle further improves the micrograph. The best surfaces for a photographic examination are obtained by a slightly more complicated cycle of polishing, etching and current reversal, the etching action being produced by a simple adjustment of the commutator of a standard Disa-Electropol machine. The sequence to be adopted may be characterised schematically by : $p5 - e3 - p5 - e2 - p5 - e2 - p5 - r2 - p5 - e2 - p5 - e2 - p5 - e2 - p5 - r2$, where p = polish, e = etch, r = reverse current, and the figures denote the duration of each part operation in seconds. The current reversal serves to eliminate the strongly adhesive film of anodic dissolution products. The whole process must be completed in one continuous operation ; any interruption will spoil the results. The electrolyte is highly corrosive and attacks even the best stainless steels. However, the attack is slight and appears only after a few hours when the polished steel parts of the circulating pump become tarnished. The machine should therefore always be drained after use. It should finally be noted that the method described is not suitable for light alloys of low silicon content.



× 400 × 0·85



× 1000 × 0·85

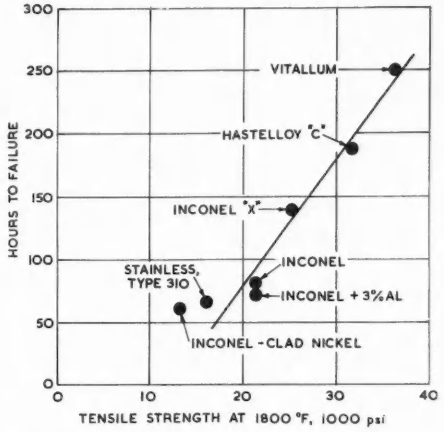
Figs. 1 and 2. **Micrographs of light alloy (11·9 Si ; 1·04 Mg ; 2·55 Ni ; 0·70 Cu ; 0·54 Fe ; rest Al) as cast.** Note that the silicon particles preserve their normal form and are not affected by electrolytic corrosion.

High-Temperature Problems in Aircraft Jet Engines and Turbo-Superchargers

By R. B. JOHNSON. (From *Metal Progress*, Vol. 59, No. 4, April, 1951, pp. 503-510, 11 illustrations.)

This paper presents a metallurgist's viewpoint of some of the problems encountered in high-temperature metals during the development of aircraft jet engines and turbo-superchargers.

THE development of aircraft gas turbines presents a different set of problems from that of other types of engines. Nevertheless, as in most aircraft applications, long engine life tends to be sacrificed for high performance. Those parts in jet engines and turbo-superchargers which operate above 1,200° F for some of their useful life are the limiting factors in fixing periods of overhaul for this type of power plant. High stresses in rotating parts come from high speeds of rotation, alternating loads, and changing thermal gradients ; stationary parts are highly stressed primarily from thermal gradients and alternating loads.



Causes of premature failure of high-temperature parts can generally be attributed to poor control of material processing or inspection, to poor control of test conditions, or to design deficiencies.

The following list of the expected operating temperatures of the high-temperature parts is presented :

Jet Engine :

Combustion liner : 900 to 1,800° F.
Diaphragm partition : 900 to 1,650° F.
Turbine wheel : 400 to 1,200° F.
Turbine bucket : 1,200 to 1,500° F.
Tail cone : 900 to 1,400° F.

Turbo-Supercharger :

Nozzle box : 1,200 to 1,700° F.
Diaphragm : 900 to 1,600° F.
Turbine wheel : 500 to 1,200° F.
Turbine bucket : 1,200 to 1,500° F.

Combustion chamber liners have a maximum temperature of the order of 1,800° F. However, owing to pressure unbalance, temperatures over 2,100° F can occur in spots, causing extreme thermal stresses and bulging into the flame passage (at 3,000° F) which quickly destroys the liner.

The performance of metals and alloys used for combustion chambers shows a definite relation to the tensile strength of the sheet metal at 1,800° F, see Fig. 1. Increased ductility is not co-related with performance, but a certain minimum ductility is believed to be essential.

Alloys with high thermal conductivity would probably give a longer life, other things being equal : high conductivity alloys, however, usually have lower mechanical strength. Most of the alloys tested have about the same conductivity at 1800° F, see Fig. 2.

Ceramic coatings are only of advantage if the coating is sufficiently thick. These are difficult to hold in place and are also unsuitable for some designs.

Another approach to longer liner life is increased wall-thickness of the combustion chamber. Since this solution makes for additional weight, it is not favoured.

Fig. 1 (left). **Relation between tensile strength at 1800° F and life of liners in a cyclic endurance test (accelerated life test).**

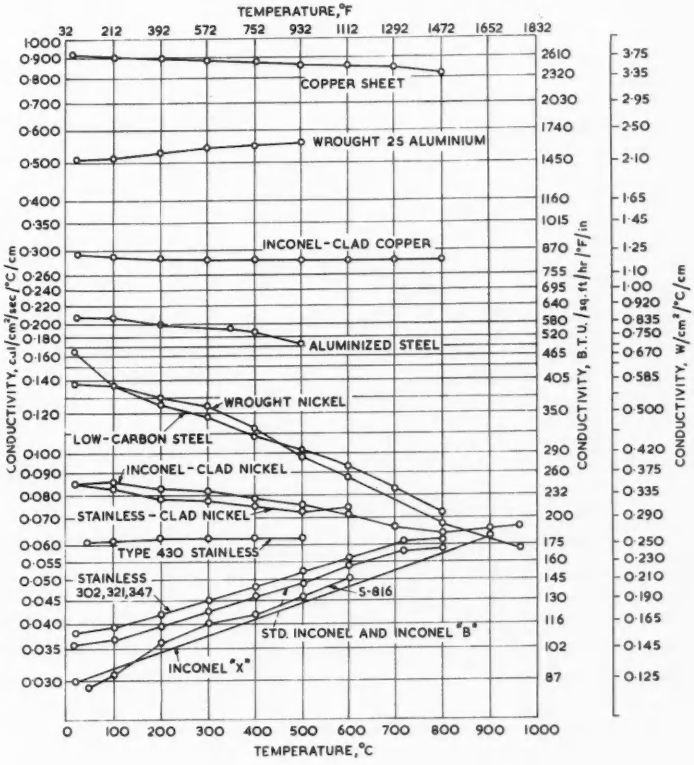


Fig. 2. **Thermal conductivity of sheet metal at various temperatures.**

Most progress toward more durable liners has, in fact, come through re-design to give proper louvre relation to airflow so as to reduce thermal gradients and pressure unbalance. Furthermore, with good design, the use of highly strategic and normally costly materials can be avoided.

Jet Engine Diaphragm Partitions are the next part met by the flow of hot gas from the combustion chamber, directing it into the turbine buckets. Their normal maximum operating temperature is 1650° F. Due to bad functioning of the combustion system, a blow-torch effect may reach the partitions, thus overheating them. On the other hand, a quenching effect may result from troubles in the water-alcohol injection (used for boosting the take-off thrust).

The resulting high thermal gradients cause distortion or localised cracking. Performance again depends on the high-temperature strength and ductility : weak and ductile materials will tend to buckle, while stronger materials crack. A good combination of properties for the diaphragm was found in Vitallium, a chromium-molybdenum-cobalt alloy.

In the laboratory, diaphragm partitions can best be tested by a thermal shock process—alternately heating to 1700° F and water-quenching in a fixed cycle. Of several materials tested, Vitallium with 0·20 to 0·35 per cent carbon was proved the best, and this superiority was confirmed by engine tests.

The *turbo-supercharger* operates on the exhaust gas of a reciprocating engine. The nozzle box, which receives the exhaust gases, is made of formed and welded sheet metal and has a cast diaphragm as an integral part. The assembly operates at temperatures between 1200 and 1650° F. If there is misalignment with the connecting lines from the engine manifold, the nozzle box may be subjected to high alternating loads.

A stainless steel used for the sheet metal portion was found to be susceptible to intergranular corrosion, owing to the fact that the nozzle box operates in a sensitizing temperature range for austenitic steels. The exact corroding medium was not established, but it could have been lead oxide or bromide, combustion products of high-octane fuel.

Nozzle Diaphragms are subject to the same general conditions, but the partitions, being of variable cross-section and directly in the path of the hot gases, are subject to somewhat more severe stresses. Fabricated diaphragms were soon abandoned in favour of castings. Recently a cast diaphragm was found to fail from development of a hard, brittle sigma phase in the microstructure. The appearance of the sigma phase was attributed to the very low carbon content of the casting (0·05 per cent), which contributes to the formation of ferrite. No sigma phase was observed in diaphragms with higher carbon content withdrawn from service.

Turbo-Supercharger and *Jet Engine Turbine Wheels* usually failed owing to forging cracks or poor metallurgical conditions at the wheel centre, i.e., flaws or low ductility. X-ray and ultrasonic methods of testing have proved extremely helpful in preventing failures in operation.

Manufacturing difficulties have eventually been overcome by the use of a continuous melting process, and the employment of a heat-treatable alloy steel for the hub and disc section, using a high temperature austenitic alloy for the rim only, the asssembly being arc-welded.

The temperature distribution of the turbine wheel has a fairly uniform gradient from about 1200° F at the rim to 400° F at the centre. The limiting factor here lies in the creep strength, as the clearance between the stationary shroud and the buckets is kept very small for reasons of efficiency. Some alloys, strong in creep and rupture resistance at design temperature, are unsuitable because of poor ductility and low yield strength at moderate temperatures.

Turbine Buckets operate between 1200 and 1500° F, and fail either by stress-rupture or fatigue, usually rupture in the case of turbo-superchargers and fatigue in the case of jet engine buckets. The turbo-bucket includes a shroud as part of the design, while engine buckets are generally shroudless.

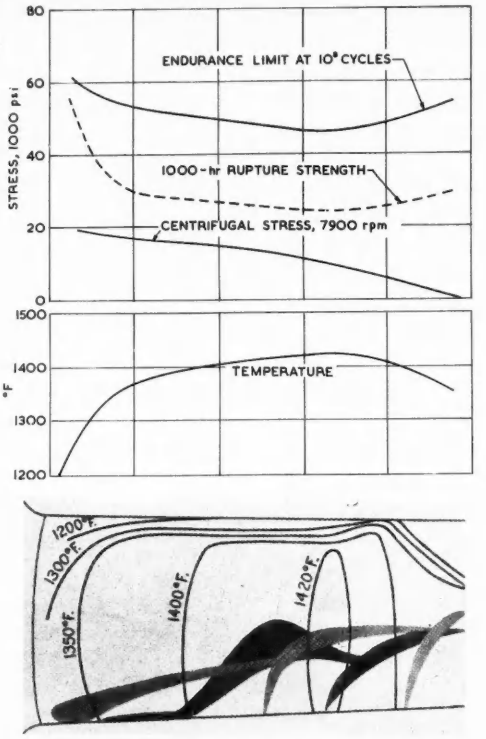


Fig. 3. (*Top*) **Average stress and temperature of a gas turbine bucket, also endurance limit at 10^8 cycles and 1000-hr rupture strength of alloy S-816.**

(*Bottom*) : **Temperature distribution on the face of a bucket and Chladni patterns (dark for 5850 cps excitation and light for 8000 cps).**

Fig. 3 gives the average (calculated) centrifugal stress along an experimental blade (made from S—816, a complicated alloy of C, Cr, Ni, Co, W, Cb and Mo) together with the operating temperature, 1000-hr stress-rupture, and the endurance limit for 10^8 cycles at the working temperatures. (The temperatures were determined by operating a bucket made of age-hardening alloy for a known period of time, and correlating the resulting hardness with age-hardening curves as affected by time and temperature). It is noteworthy that there is a considerable margin between the strength available and the average centrifugal stress. Even so, the majority of failures have been $\frac{3}{4}$ in. below the tip on the exit edge.

Fig. 3 also shows the temperature distribution of the same bucket on which are superimposed sand pattern lines of two exciting frequencies. A correlation probably exists between areas of high stress and failure, though the patterns have been made at room temperature and the exact effect of high temperatures on the patterns is not known.

The metallographic analysis to determine whether the failures were of the stress-rupture or fatigue type was based on whether the fracture was intergranular

or transgranular, this being dependent on the strain rate and temperature. The assumption that intergranular failure indicates stress-rupture is believed to be sound for the alloys employed, at normal operating times and temperatures.

The high-frequency Chladni patterns that correlate with the zone of failure (Fig. 3) indicate that failure under resonant conditions develops fairly quickly if the stresses are above the endurance limit. Since the time interval to cause fatigue failure is small, a material with high fatigue strength and relatively low stress-rupture strength could operate well in a design with fairly high vibrating stress.

The exact point where failure started is sometimes hard to establish. It may start by thermal shock or by stress-rupture, then the crack may progress by fatigue, and finally the transgranular portion of a crack may again become intergranular from increased load or reduced cross-section.

Manufacturing Precautions. Buckets which failed by fatigue have shown neither a different distribution of grain size nor a different hardness from those which have run satisfactorily for the same period of time. Process control throughout is extremely important. A particular hazard in forging and heat-treatment is the tendency towards the formation of very large ("elephant") grains. Conditions for producing these grains are a critical amount of deformation during cold-finishing and a subsequent high solution-treating temperature. Variable grain size is thought to be unfavourable to best bucket performance—that is, resistance to thermal shock and vibrating loads.

Many of the high-temperature alloys tend to have a low ductility between 1200 and 1500° F. This is just below the normal forging range, and so forging cannot be performed safely at too low a temperature. This low-ductility range may also prove harmful to engine operation. Any misalignment in assembly or design configuration that requires some plastic flow in the initial period of running to reduce stress concentration requires ductility. With low ductility, stresses or thermal shocks could become high enough to cause rupture.

The jet engine tail cone structure is made of welded stainless sheet. It is subject to some unbalanced pressures, but temperature gradients encountered are generally not very high. Stronger materials improve life, but the real solution lies again in improved design.

ITALY

New Trends in the Design of Metadyne Generators

By A. CARRER. (From *L'Elettrotecnica*, Vol. 37, No. 12, December, 1950, pp. 533-542, 20 illustrations.)

This article describes a machine capable of rotating at a theoretically constant speed, although without regulating windings or regulator dynamo. The secondary current is independent of the primary or secondary voltages and is proportional to an externally controlled current. The machine has been employed as a traction unit on Decauville narrow-gauge railways. A special flameproof ventilating system is also described. The calculated performance has been confirmed by tests.

THE metadynes are machines which maintain a practically constant speed of rotation under certain conditions. The design which is the subject of this article is a machine in which the secondary current varies linearly with the secondary voltage and is also proportional to an externally controlled m.m.f., with the result that it can be given any required characteristic, independent of the primary voltage. The velocity is generally variable but can be made constant, in which case it depends only on an externally controlled e.m.f. and is independent of the primary and secondary voltages.

DESCRIPTION AND CIRCUIT CHARACTERISTICS.

The theoretical circuit is shown in Fig. 1. It shows a single-cycle machine with four equally spaced brushes 1, 2, 3 and 4. The rotor has a clockwise rotation. The primary current I_1 passes tnrough brushes 1 and 3 and this circuit is connected to the primary supply voltage V_{31} provided by an external source. The secondary circuit with the brushes 2 and 4 has a current I_2 flowing through it and ends at the terminals 2 and 4, which have a potential V_{24} which may have any positive or negative value, according to the load.

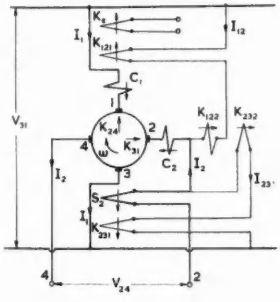


Fig. 1. **Theoretical circuit diagram of the metadyne generator.**

The stator of the machine has the following windings :—primary and secondary windings C_1 and C_2 ; a stabiliser secondary winding S_2 ; the windings K_{121} and K_{122} controlled by the voltages of brushes 1 and 2 ; the windings K_{231} and K_{232} controlled by the voltages of brushes 1 and 3 ; and the externally controlled winding K_e. Fig. 1 shows these windings in their theoretical positions.

The positive directions of the currents and m.m.f.'s are indicated by arrows in the figure. The symbols K and C with various subscripts will denote constant values depending on the design characteristics of the machine, whereas I_{12} and I_{23} are the currents flowing through the windings K_{121}, K_{122} and K_{231}, K_{232}. Assuming that the circuit resistances and losses are negligible and that saturation phenomena do not occur in the magnetic materials, the equations of the metadyne generator can be written as follows :—

$$(K_{31} - C_2)I_2 + K_{122}I_{12} + K_{232}I_{23} = V_{31}/\omega$$
$$(K_{24} - C_1)I_1 - S_2I_2 + K_{121}I_{12} - K_{231}I_{23} + K_eI_e = V_{24}/\omega \quad .. \quad .. \quad (1)$$

ω being the angular velocity of rotation. Assuming that $K_{31} = C_2$, $K_{24} = C_1$, and $K_{121} = K_{122} = K_{231} = K_{232} = K$, these equations reduce to

$$K(I_{12} + I_{23}) = V_{31}/\omega$$
$$K(I_{12} - I_{23}) = (V_{24}/\omega) + S_2I_2 - K_eI_e \quad .. \quad (2)$$

and denoting by $r/2$ the common resistance of the four K windings, we may write

$$K(V_{21} + V_{32})/r = V_{31}/\omega$$
$$K(V_{21} - V_{32})/r = (V_{24}/\omega) + S_2I_2 - K_cI_c \quad (3)$$

Since $V_{21} + V_{32} = V_{31}$ and $V_{21} - V_{32} = V_{21} - V_{41} = V_{21} + V_{14} = V_{24}$,

the equations become finally

$$KV_{31}/r = V_{31}/\omega$$
$$KV_{24}/r = (V_{24}/\omega) + S_2I_2 - K_cI_c \quad .. \quad (4)$$

The first of these two equations, rewritten as

$$\omega = r/K \quad .. \quad .. \quad .. \quad (4a)$$

indicates that the angular velocity ω of the machine is constant and depends on the characteristics of the windings K, but not on the primary and secondary voltages V_{31} and V_{24}. When eq. (4a) is substituted in the second equation of (4), this is reduced to

$$I_2 = K_cI_c/S_2 \quad .. \quad .. \quad (5)$$

The stator considered has four equal pole segments, the axes of which bisect the primary and secondary axes, as shown in Fig. 2. The relation $\omega = r/K$ indicates, therefore, that the m.m.f.'s supplied by the K windings automatically assume the required values, since, when the machine is rotating at an angular velocity ω, the internal e.m.f.'s $E_{21} = E_{34}$ and $E_{32} = E_{41}$ are exactly balanced by the externally applied voltages $V_{21} = V_{34}$ and $V_{32} = V_{41}$, with the result that the e.m.f.'s E_{31} and E_{24} generated inside the machine compensate exactly the externally applied voltages V_{31} and V_{24} whatever their values may be.

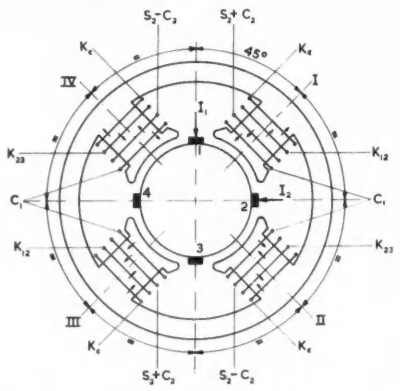


Fig. 2. **Constructional arrangement of the metadyne generator.**

Thus, eq. (5) shows that I_2 is a linear function of the controlling current I_c, which may have any positive or negative value, and that I_2 does not depend on the primary and secondary voltages V_{31} and V_{24}.

Another way of explaining the functioning of the machine is as follows :—

1. The K windings provide each pole with m.m.f.'s which are proportional to the potential differences obtained between the brushes immediately adjacent to the pole considered, so that, as in the case of machines with shunt excitation, the speed of rotation is maintained constant, irrespective of the values of the applied voltages.

2. The windings C_1 and C_2 are determined so as to obtain total compensation of the armature reaction in order to maintain the conditions given under (1) for all values of I_1 and I_2.

3. The winding K_c with the controlling current I_c generates an m.m.f. acting on the stabiliser winding S_2 and thus requiring a current I_2 with a value satisfying eq. (5), so that the conditions outlined under (1) above are not altered. The behaviour of the system is stable because, if the ampere-turns produced by K_c exceed those generated by S_2, the excess m.m.f. will tend to increase the secondary current I_2, whereas if the ampere-turns of S_2 exceed those of K_c, the contrary will occur, thus tending to restore the state of equilibrium.

In addition, theoretically, the machine must always satisfy at its operating speed the condition

$$V_{31}I_1 = V_{23}I_2 \quad .. \quad .. \quad (6)$$

This condition is, in fact, fulfilled, because if, for a given pair of values for the voltages V_{31} and V_{24} applied to the brushes, the power developed by the machine in one of its two primary or secondary circuits differs from that absorbed by the other circuit, the rotor will slow down or accelerate, depending on whether the power generated or absorbed is predominant, and this corresponds to a reduction or increase in the value of the e.m.f. E_{31} and an increase or reduction of the current I_1, so that, in any case, there will be a tendency to re-establish equilibrium between the power generated and absorbed by the machine.

A further result is that the value of E_{24} tends to diminish or increase correspondingly, and this similarly affects the value of the current I_2. However, this action is opposed by the m.m.f. K_cI_c, with the result that after the occurrence of a transient variation, the conditions corresponding to eqs. (4a) or (5) are re-established. The effects of losses and magnetic saturation can be kept relatively small by giving ample proportions to the electrical and magnetic circuits of the machine.

The basic diagram of Fig. 1 corresponds to the constructional arrangement of Fig. 2. In this, the directions indicated for the m.m.f.'s are those, assumed to be positive, which correspond to the positive directions of the currents shown in Fig. 1. As the same current flows through the windings C_2 and S_2, the design is simplified by combining these in the form of a winding $C_2 + S_2$ on the pole segments I and III and a winding $C_2 - S_2$ on poles II and IV. Similarly, the windings K_{121} and K_{122} are combined in a single winding K_{12} appearing on poles I and III, while K_{231} and K_{232} are replaced by a single winding on II and IV. The winding K_c appears on all four pole segments.

APPLICATION OF THE METADYNE MACHINE FOR TRACTION PURPOSES

The machine described in the previous sections has been employed in traction units fed by accumulators and used on Decauville railways. The following conditions had to be fulfilled :—

The battery current and the motor speed should not exceed certain limits. The motor torque should be positive below the maximum speed limit and negative above it. When the controller is shifted to the zero position, the motors must have a braking effect on the motion, regardless of its direction. The driving torque plotted against motor speed must, therefore, be fairly constant over the major portion of the speed range, dropping to zero at a critical value ω_0 and reaching negative values of torque at higher speeds.

These requirements are fulfilled by the circuit consisting of one metadyne generator and two motors illustrated in Fig. 3. The metadyne windings, with the exception of the K_c winding, which has particular features, are not repeated in this figure.

The two motors M are connected in a left-sided "figure eight" connection to the metadyne generator MT. The constant dynamo excitation obtained from the supply line can be reversed in order to reverse the motion of the traction unit. The torque/speed characteristic is similar to the curve of the secondary current I_2 supplied to the motors as a function of the motor speed, and also similar to the characteristic $I_2 = f(V_{41})$, since, in the ideal case, $V_{41} \propto \omega$. But, according to eq. (5), I_2 is proportional to I_c, so that, ultimately, the problem is to obtain a characteristic

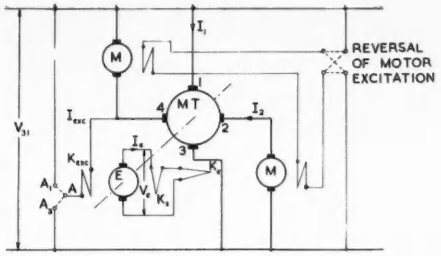


Fig. 3. **Theoretical diagram of metadyne installation for traction units used on Decauville railways.**

$$I_e = f(V_{41}) \quad .. \quad .. \quad (7)$$

similar to the torque/speed characteristic which is required.

This has been achieved by means of an arrangement, previously used by Prof. G. M. Pestarini, in which an exciter dynamo E is excited by a current taken from the metadyne generator brushes and operating under strong saturation conditions. A diagram of the arrangement is shown in Fig. 3.

If the points A and A_3 are connected together, the current I_{exc} of the exciter excitation will follow the straight line, in Fig. 4, representing the voltage $V_{34} \propto I_{exc}$ (driving condition) and, therefore, also determining V_e and the current I_e which excites the metadynamo. The qualitative relationship is, therefore, given by : $V_e \propto I_e \propto I_2 = f(V_{24})$.

If A and A_1 are connected together, I_{exc} will vary according to the curve $V_{41} \propto I_{exc}$ (stopping and braking when $\omega \neq 0$) and the corresponding variation of $V_e \propto I_e \propto I_2 = f(V_{24})$ is shown in Fig. 4. In this condition, the motors will brake, whatever may be the direction of motion.

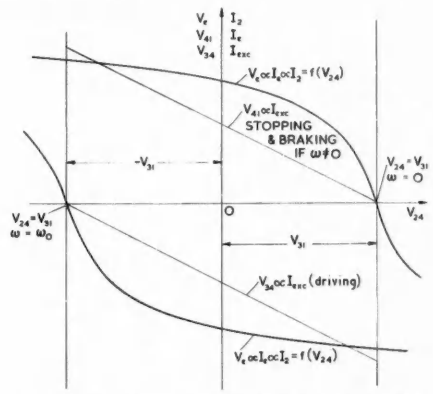


Fig. 4. **Characteristics of currents $I_1 = f(V_{24})$ obtainable by means of the circuit arrangement shown in Fig. 3.**

The current I_0 taken from the batteries is determined by

$$I_0 = I_1 + I_2 = I_2[1 + (V_{24}/V_{31})] \quad .. \quad (8)$$

taking account of eq. (6). This clearly shows that it is possible to adjust the characteristic $V_e = f(V_{24})$ in such a way that the value of I_0 will be maintained between predetermined limits.

EXPERIMENTAL RESULTS

The tests were carried out on a metadyne which had the following windings : $K_{31} = K_{24} = 8{\cdot}75$ turns ; $C_1 = C_2 = 9$ turns ; $S_2 = 4$ turns ; $K_e = 925$ turns. Thus, $C_2 + S_2 = 13$ turns, and $C_2 - S_2 = 5$ turns.

The compensation of the armature reaction is practically complete, because the slight excess of C_1 and C_2 over K_{31} and K_{34} is cancelled out by the greater efficiency, for an equal number of ampere-turns generated, of an armature winding relatively to that of a field winding. This was confirmed by tests, which showed that the mean magnetic characteristic $V_{24} = f(I_{13})$, obtained with an externally controlled current flowing through the rotor between the brushes 1 and 3, is greater than the characteristic $V_{24} = f(I_e)$ obtained at the same rotor speed of 2200 rpm by exciting the machine with a current flowing through the winding K_e.

Furthermore, it was found that the characteristic $V_{23} = V_{31} = f(I_{23})$, plotted against the ampere-turns per pole for the same rotor speed, gave voltages which were approximately only half the corresponding values of the two previous curves. The $V_{23} = f(I_{23})$ characteristic was obtained by exciting the machine with the K-type windings arranged on the polar segments II and IV, which, in this case, were the only poles generating the magnetic flux.

The K windings not shown in Fig. 3 were given different dimensions in the experimental design because it was foreseen that the windings K_{12} on the pole segments I and III would be subjected to greater thermal stresses, under normal operating conditions, than the windings K_{23} on II and IV. The values chosen were, therefore : $K_{12} = 520$ turns, and $K_{23} = 1078$ turns.

Before carrying out the main tests, the circuit resistances of the windings K_{12} and K_{23} were adjusted so that both would satisfy, as well as possible, the condition $\omega = r/K$, this being obtained, in practice, either by adjusting the m.m.f.'s produced by K_{12} and K_{23} until they gave $V_{24} = V_{31}$ and $V_{24} = -V_{31}$, respectively, or by determining the circuits so that when the metadyne is on no-load ($I_2 = 0$), the speed of the machine will be the same for both $V_{24} = V_{31}$ and $V_{24} = -V_{31}$.

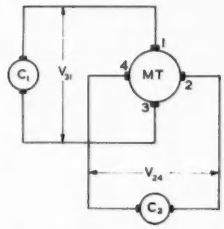


Fig. 5. **Theoretical circuit used for measurements.**

The circuit used for the tests is shown in Fig. 5. The metadyne MT was supplied with a constant voltage by means of a d.c. machine C_1, and another d.c. machine C_2 was inserted in the secondary circuit.

The value and the polarity of the secondary voltage were altered by varying the excitation of the machine C_2.

Using primary applied voltage values (V_{31}) equal to 90 and 45 volts, the primary and secondary current characteristics

$$I_1 = f(V_{24}), \quad I_2 = f(V_{24})$$

were obtained for values of the exciting current I_e from + 0·7 to — 0·7 amperes regarded as parameters. These results clearly showed that for the same values of V_{24} and I_e, the value of I_1 for $V_{31} = 45$ volts is double the corresponding value for $V_{31} = 90$ volts, indicating that the theoretical conditions were satisfactorily verified in practice. Furthermore, it was found that the values of I_2 were proportional to those of the controlling current I_e and, for a given value of this current, independent, within certain limits, of the primary and secondary voltages V_{31} and V_{24}.

The agreement between the characteristics obtained for $V_{31} = 45$ volts and 90 volts was particularly satisfactory for secondary voltage values between approximately + 50 and — 50 volts. Outside this range, slightly less close agreement was obtained, with I_e equal

to 0·7 and — 0·7 A, respectively. This may be due to the fact that, under conditions corresponding to heavy overload, when the primary current assumes very high values, the effects due to ohmic drops and to stray fluxes are no longer negligible and the theoretical relations for the m.m.f.'s are then only approximately valid.

The measurements were taken with the windings K_{12} and K_{23} connected to the brushes 4, 3 and 1, 4, respectively. This arrangement had no appreciable effect on the results, since the e.m.f.'s E_{21} and E_{34}, as well as E_{32} and E_{41}, are always equal. Differences occurring in the I_{12} and I_{23} characteristics, plotted as functions of V_{24}, were attributed to temperature and winding resistance variations.

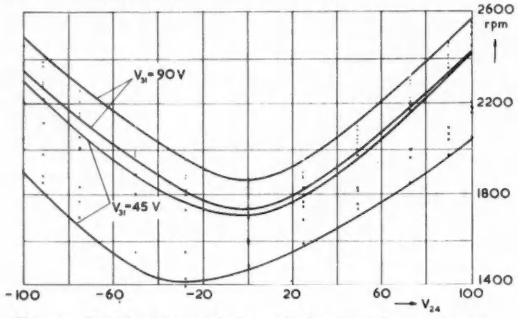


Fig. 6. **Speed characteristics of the metadyne, plotted against the secondary voltage V_{24}, for V_{31} = 90 and 45 volts ; and for I_e = 0·7, 0·35, 0, — 0·35 and — 0·7 amperes.**

As shown in Fig. 6, the speed characteristics of the metadyne were determined as functions of the secondary voltage V_{24} for primary voltages V_{31} of 90 and 45 volts, the lower speeds obtained with the lower value for the primary voltage being due to the machine operating under less saturated conditions.

Further measurements were made to determine the characteristics shown in Fig. 7a, using the exciter dynamo indicated in Fig. 3 and exciting this dynamo by means of currents taken from the brush pairs (1, 4) ; (2, 4) ; and (3, 4). The figure shows I_1 and I_2 plotted against the secondary voltage V_{24}. Fig. 7b shows corresponding values of the exciting current I_{exc} of the exciter dynamo and the controlling current I_e also plotted against V_{24}. The theory is confirmed by these results.

In order to increase the variation of the secondary current I_2, in relation to the value of the secondary voltage V_{24}, for which $I_2 = 0$, the exciter dynamo was excited not only by means of the winding K_{exc} of Fig. 3, but also with the series-type winding K_s, through which the current I_e flows from the exciter. The winding K_s is arranged so that its ampere-turns will always assist those of the winding K_{exc}. Obviously, since the load applied to the exciter dynamo by the winding K_e is constant, the ampere-turns produced by K_s will be proportional to the voltage V_e generated by the exciter. Therefore, disregarding the internal ohmic losses of the machine, the introduction of the winding K_s in the manner described will have the same effect as a reduction in the air-gap of the exciter dynamo. The m.m.f. generated by K_s must be adjusted so that it will not exceed that equivalent to the elimination of the air-gap, because in such a case the machine would be in a state of self-excitation and would not always produce a voltage of the same sign as that which has to be generated by the m.m.f. in the winding K_{exc}.

OPERATION OF THE METADYNE TRACTION UNIT FOR DECAUVILLE RAILWAYS

It was previously stated that a " left-hand eight " circuit arrangement was adopted for the dynamo and its

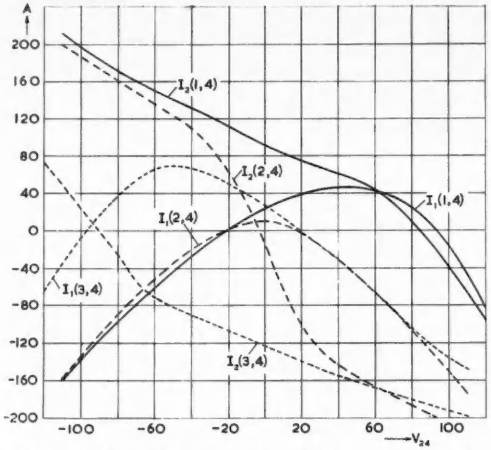


Fig. 7a. **Characteristics : $I_2(1, 4) = f(V_{24})$; $I_2(2, 4) = f(V_{24})$; and $I_2(3, 4) = f(V_{24})$.**

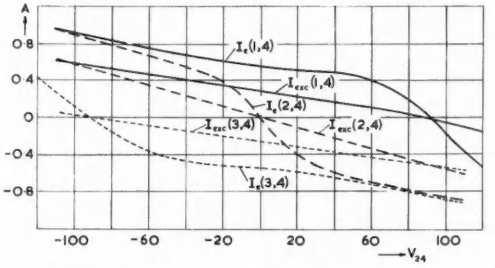


Fig. 7b. **Characteristics $I_{exc}(1, 4)$, $I_{exc}(2, 4)$, $I_{exc}(3, 4)$ as functions of V_{24}, and corresponding curves for $I_e(1, 4)$, $I_e(2, 4)$ and $I_e(3, 4)$, related to the characteristics of Fig. 7a.**

two motors. Theoretically, it was indifferent whether a right or a left hand arrangement was used. However, having found that the characteristics of I_2 as a function of the secondary voltage V_{24} were curves which were concave upwards, it was considered preferable for operating conditions to arrange for negative values of I_2 in order to obtain characteristics with a smaller slope for the lower values of the motor speed.

The equations derived above were based on the assumption that the currents of brushes 1 and 3, and hence of brushes 2 and 4, were of equal value. However, it is known that this condition is not satisfied when a metadyne is in an " eight " circuit arrangement and has only one commutator, particularly if the resultant voltages of the branch circuits with the motors are not equal. This occurs, for instance, when, owing to

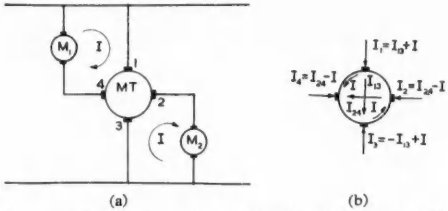


Fig. 8a. **Additional currents I in the " left-hand eight " circuit arrangement.**

Fig. 8b. **Normal and additional currents in the armature of the metadyne generator.**

insufficient adhesion, the wheels controlled by one of the motors skid on the rails. Then, the e.m.f. produced by the motor M_1 rotating at the higher speed (Fig. 8a) will prevail over the e.m.f.'s $E_{41} = E_{32}$ generated in the metadyne armature, and these, in turn, will be greater than the e.m.f. due to the lower-speed motor M_2.

The armature currents can be regarded as the result of super-imposing on the normal primary and secondary currents I_{13} and I_{24} the additional currents I circulating in the loops of the figure-eight arrangement, as shown in Fig. 8b. Regarding the conversion of energy which takes place in the machine, it is known that, in addition to the relation (6), and disregarding losses, we have :

$$V_{41}I = V_{32}I \quad .. \quad .. \quad (9)$$

since, on the basis of the simplifying assumptions, $V_{41} = E_{41} = E_{32} = V_{32}$.

In the particular case considered, corresponding to the arrangement of Fig. 3, it is easily verified that if a negative current I_2 flows through the motors or if these are operating under driving conditions, the presence of the additional currents I will correspond to a reduction in the magnitude of the current passing through the armature of M_1 and, therefore, to a decrease in its driving torque, while also resulting in an increase of the current through the slower-speed motor M_2, equivalent to an increase in its driving torque. The equipment is, therefore, self-regulating in regard to differences in motor speeds.

Conversely, if the current I_2 flowing through the motors is positive, or if the motors are braking and recovering power, the armature of the higher-speed motor M_1 will have a current increasing in magnitude, while the contrary will be the case with M_2. This is a favourable feature for the traction unit, since, under braking conditions, the wheels which ultimately slide are those controlled by the motor with the slower speed.

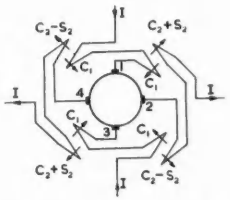


Fig. 9. **Additional currents and m.m.f.'s generated by these in the field of the metadyne generator.**

When the compensating (primary and secondary) windings and the secondary stabiliser winding are arranged on the stator of the metadyne as shown in Fig. 9, in which the brushes are in their theoretical positions, the additional currents I will not produce resultant m.m.f.'s in either the rotor or the field system. Therefore, eqs. (4) and (6) are still valid, as well as eq. (9) provided that I_1 is taken as denoting the elementary current I_{13}, and I_2 as denoting the current I_{24}. Taking account of eq. (5), we then obtain

$$I_{24} = K_e I_e / S_2 \quad .. \quad .. \quad (10)$$

Therefore, the behaviour of the equipment is as follows, in the case of unbalanced loads or when $I_1 \neq I_3$ and $I_2 \neq I_4$:—Either as a result of total compensation of the m.m.f.'s of the armature reaction, or owing to the particular design features of the armature and field windings of the metadyne, the currents I_{13}, I_{24} and I flowing through the armature of the metadyne will generate only the m.m.f. $S_2 I_{24}$, which must compensate the m.m.f. $K_e I_e$ at any operating speed. The power absorbed by the motor M_1 is (Fig. 8a)

$$V_{41}I_4 = -V_{41}(I_{24} + I)$$

and that of M_2 is

$$-V_{31}I_2 = -V_{32}(I_{24} - I)$$

so that the total power absorbed by the motors M_1 and M_2 is

$$-2V_{41}I_{24}$$

which is equal to the power absorbed by M_1 and M_2 when the additional currents are zero and only the normal currents I_{13} and I_{24} flow through the metadyne. Thus, the total power of the motors controlled by the metadyne is independent of possible unbalanced loads in the two branches of the circuit. This conclusion applies for the theoretical case, with given values for the exciting m.m.f. $K_e I_e$ and for the primary and secondary voltages V_{31} and V_{24}.

A further consequence of the above is that if, for instance, $I_4 = 0$, which may occur if the circuit of motor M_1 is opened and the equipment operates with motor M_2 only, we have

$$I_{24} = -I \; ; \; I_1 = I_{13} + I = I_{13} - I_{24} \; ; \; I_2 = I_{24} - I = -2I_{24} \; ; \; I_3 = -I_{13} - I_{24} \; ; \; I_4 = I_{24} + I = 0$$

and the motor M_2 absorbs a power equal to $-2V_{41}I_{24}$, or twice the power which it would normally absorb if both motors were connected to the metadyne. The above considerations also apply when I flows in the opposite direction, or when M_1 is operating alone.

Experimental results gave a satisfactory confirmation of the theoretical behaviour described in the foregoing lines. The tests were carried out on a metadyne with a winding arrangement slightly different from that of the final design, but further tests should confirm the basic characteristics already obtained.

Finally, it may be added that the operating characteristics will remain unchanged if two or more motors are used in parallel, instead of a single motor, in each branch of the " figure eight " circuit.

DESIGN FEATURES OF VENTILATING SYSTEM FOR FLAMEPROOF EQUIPMENT

The construction includes a special ventilating system which enables it to operate in atmospheres containing explosive gases. It was suggested that a system be evolved in which the ventilating air would be able to pass through the axial ducts which are usually provided in the armature laminations, without, however, going through the space between the rotor and the stator, in which sparks may occur over the commutator.

This was achieved by using a shaft having hollow end sections communicating through radial passages with two vanes situated at the two ends of the axial channels in the armature system. The ventilating air flows through these ducts and is ejected by the fan.

The efficiency of the ventilating system was tested in the following manner. A given operating condition of the metadyne group was first determined, in accordance with its natural characteristics, maintaining the primary and secondary voltages V_{31} and V_{24} constant. The group was then first operated for 6 hours without ventilation, by obstructing the inlet and outlet orifices in the shaft. Readings for determining the temperature rises were taken by means of resistance measurements. The group was then immediately started up again with its ventilating system freely operating, and was run for another 2 hr 15 min.

Readings of the voltages, currents and running speeds of the group were also recorded before and after each stage of the test, and gave the following results :—

	Measured Values			
	At beginning of test	After first 6-hr run	After second 2¼-hr run	
V_{31}	90	90	90	volts
V_{24}	0	0	0	,,
I_1	28	27	26	amps
I_2	144	124	126	,,
I_{41}	0·89	0·65	0·67	,,
I_{34}	1·78	1·25	1·31	,,
I_{exc}	1·50	1·10	1·15	,,
I_e	0·59	0·48	0·51	,,
n	1640	1900	1975	rpm

The temperature rises in °C, measured for the various parts of the machine, are given in the following table :—

	Temperature rise °C		Reduction in temperature obtained by ventilation %
	after 1st run	after 2nd run	
Metadyne armat. winding	126·5	88·5	30·0
Exciter armature winding	75·5	47·5	37·1
Series windings C_1, C_2 + S_2 and C_2 — S_2	85·5*	61·2*	28·4
Shunt windings K_{41} and K_{34}	132·5*	115·5*	12·8
Winding K_e	109·5	91·5	16·4
Winding C_{exc}	124·5	106·5	14·5
Outer casing	81·0	67·0	17·3

* Mean values.

These results show that considerable advantages were obtained with the ventilating system, particularly in regard to the armature windings and the series windings close to the rotor, the improvement being less pronounced for the windings K_{41}, K_{34} and K_e which were situated inside the casing at a further distance from the rotor.

Determination of the Fatigue Limit of Metals by means of a Three-Ring Test Machine

By M. M. KHRUSHCHOV and M. A. BABICHEV. (From *Zavodskaya Laboratoriya, Russia*, Vol. 15, No. 8, 1949, pp. 962-967, 6 illustrations.)

FOR testing the fatigue limit of bearing alloys cast in thin layers in a steel holder, the author has designed a three-ring test machine, Fig. 1. The test sample (1) is placed between three rings, one of which is a driving ring (2) and the other two the outer rings of self-aligning ball-bearings. The upper ring (3) is supported by a lever (4) ; the lever is fixed at one end to the frame, its other end carrying a suspended weight. The test is carried out while applying a constant load ; the authors used a maximum load of 100 kg. The driving ring (2) is driven by an electric motor, to which it is coupled by means of an elastic coupling. The authors used a motor running at 1000 to 1500 rpm.

The diameters of the three rings and the ring to be tested are equal, so that, therefore, there will be three stress cycles per revolution of the driven ring. Thus, for a motor speed of 1500 rpm there will be 4500 stress cycles per minute. The total number of stress cycles for a given test sample is recorded by a counter coupled to the driving ring.

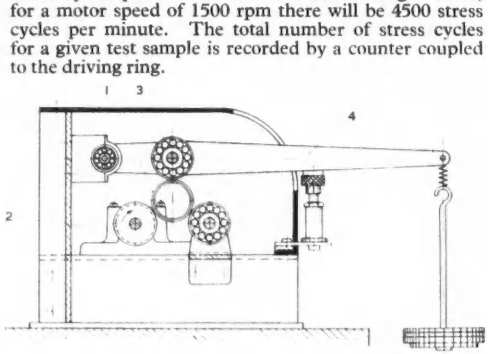


Fig. 1. **Schematic drawing of the three-ring test machine.**
1—ring to be tested ; 2—driving ring ;
3—top ring to which the load is applied ;
4—load-carrying lever.

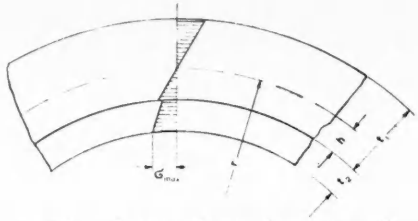


Fig. 2. **Schematic stress diagram in a cross-section of a bimetallic ring due to the effect of the bending moment M_{max}.**

The maximum tensile stress will occur at the inside diameter of the ring under a point of contact with the supporting rings. Its value is determined by the formula :

$$\sigma_{max} = \frac{3\,M_{max}}{b\,t_1^2}\,\alpha = \frac{1{\cdot}8\,Pr}{\pi\,b\,t_1^2}\,\alpha \quad .. \quad (1)$$

where $M_{max} = 0{\cdot}6\,Pr/\pi$ is the maximum bending moment, P is the force acting on the test sample, r is the mean radius of the test sample, and α is determined by the formula :

$$\alpha = \frac{m + k}{\frac{1}{c}(1 - m^3) + \frac{1}{c}m^3 + (m + k)^3 - m^3},$$

and

$$m = \frac{h}{t_1} = \frac{(1 - c\,k^2)}{2\,(1 + c\,k)}$$

where h is the distance between the plane of division of the two metals and the neutral axis (Fig. 2), $c = E_2/E_1$ is the ratio of the elasticity moduli of the two materials, $k = t_2/t_1$ is the thickness ratio of the two materials, and b is the width of the ring.

It is essential that the thicknesses of both materials of the ring be determined with very high accuracy.

If the test ring is homogeneous (i.e., made of one material only), the maximum stress is determined by the formula :

$$\sigma_{max} = \frac{3{\cdot}6\,Pr}{\pi\,b\,t_1^2}$$

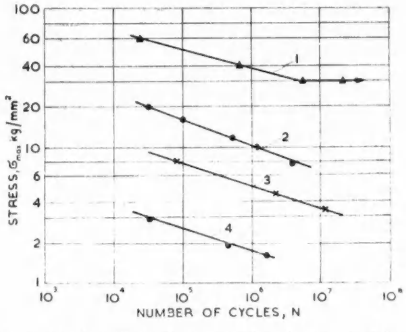


Fig. 3. **Fatigue limit diagrams of various materials.**
1—homogeneous ring made of steel,
2—steel ring lined with tin-lead bronze,
3—steel ring lined with babbit,
4—steel ring lined with lead.

The authors have determined the fatigue limits of various materials ; the test results obtained are given in Fig. 3. Optimum dimensions of the test samples are : outer dia. of the steel ring 62 mm, inner dia. 59 mm, width 21 mm, thickness of the bearing metal layer 2 to 10 mm.

New Materials, Processes and Equipment

NEW OXY-ACETYLENE PROCESS

Sand encrustations, fins, pads, chaplets or chill nails, and other forms of excess metal can be removed from castings quickly, easily, and economically by means of an oxy-acetylene method recently developed by Linde Air Products Company, New York 17, N.Y. The new process, called "powder-washing," utilises a special blowpipe, equipped with an external powder-washing attachment. With this apparatus, an iron-rich powder is fed through oxy-acetylene pre-heat flames into a low-velocity oxygen stream, where it burns and produces superheated liquid iron oxide. Heat from the combustion of the powder and from the slag simplifies and speeds the removal of metal and metal-sand mixtures. Wherever the powder-fed flame is directed against a casting, the metal surface is brought quickly to kindling temperature, and then it is oxidised and blown away by the oxygen stream.

After powder-washing, the surfaces of castings are left smooth, clean, and to close tolerance. There is no undercutting, and no torn metal. The washing nozzle has a large centre hole, through which the low-velocity oxygen stream is discharged. Around the large hole is a ring of 10 pre-heat flame ports. The powder is discharged from a flat tube above the nozzle. A pneumatic dispenser supplies the powder. Compressed air at 6 psi carries the powder through a separate hose to the powder attachment mounted on the blowpipes. Regulators, accessories, and oxygen and acetylene supply are the same as used with ordinary hand-cutting blowpipes.

NEW CHEMICAL BATH TO REMOVE SCALE FROM FORGINGS

One of the most difficult problems in production heat-treatment of steel forgings is the removal of furnace scale. Now the Pennsylvania Salt Manufacturing Company, Philadelphia, Pa., is marketing a pre-heat chemical bath which completely removes this scale during quenching and has accounted for cost savings of 90 per cent over previous methods used in industrial production. The bath is made up of a new product, Pennsalt SR-4, dissolved in weak muriatic acid and water.

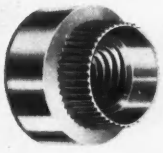
The bath requires no heating and is made up in ordinary rubber lined tanks. Dipping baskets can be made of simple sheet iron. Parts covered with forging scale are immersed in the bath for five minutes and then may be placed directly into heat-treatment furnaces or can be stored for later heat-treatment.

The forgings are heat-treated at a temperature range from 1500° to 1600° F and soaked at a temperature for the minimum time consistent with good metallurgical practice. An additional saving results from the fact that the forgings can be heat-treated in a non-reducing atmosphere or without a prepared atmosphere. Conventional expensive sand or shot blasting is completely eliminated in most operations. When the forgings treated with SR-4 are water-quenched, the scale actually blasts off from all surfaces, leaving them perfectly clean for subsequent machining.

Laboratory tests as well as plant operations have shown that the SR-4 bath provides complete removal of scale from carbon steel forgings, even from deep indentations and blind holes difficult to reach with sand or shot blasting.

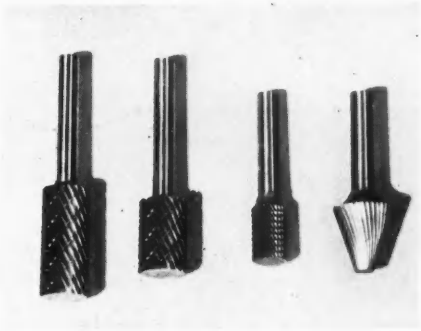
SERRATED ANCHOR RIVET BUSH

An improved product which will be welcomed by all who are concerned with the fastening of metal sheets is the "Precision" Patent Serrated Anchor Rivet Bush introduced recently and now in production by the Precision Screw & Manufacturing Co. Ltd., Willenhall, Staffs. A feature of the Anchor Rivet Bush is its finely tapered and bevelled shank provided with serrations which cut their way into the sheet and effectively prevent the bush from turning after riveting. A point of particular interest is that the material selected for the manufacture of these bushes is hard enough to cut the serrations in the sheet, but soft enough to rivet quite easily.



TUNGSTEN CARBIDE ROTARY CUTTERS AND BURRS

Tungsten Carbide Rotary Cutters and Burrs are now being manufactured by Protolite Ltd. in a wide variety of shapes and cuts to meet the needs of the metal-working, plastics, and ceramics industries. These tools can cut hardened steel without difficulty, and the precision ground teeth ensure a smooth cutting action under all conditions of use.

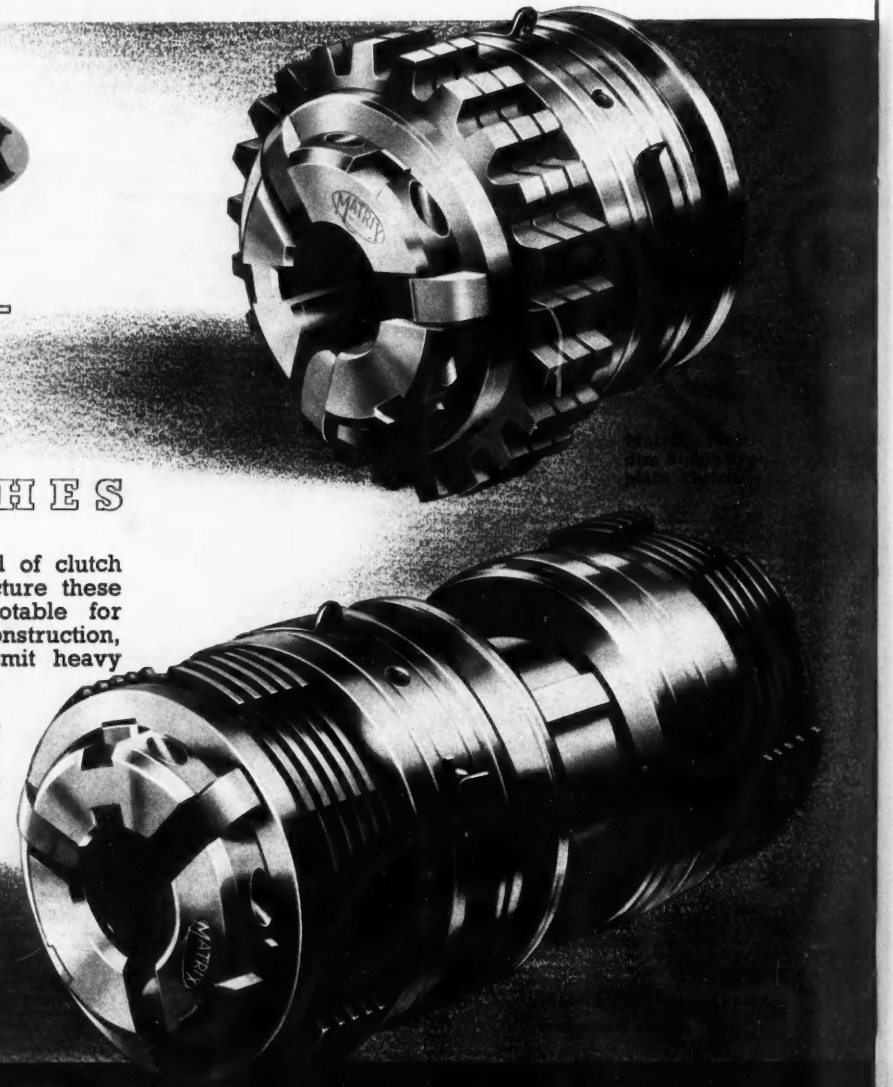


High load capacity

YET COMPACT IN SIZE

MATRIX
COVENTRY GAUGE & TOOL COMPANY LTD.

MULTI-DISC CLUTCHES



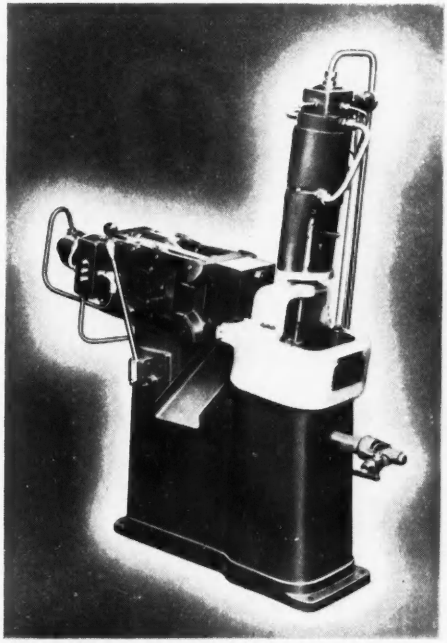
Foremost in the field of clutch design and manufacture these Matrix types are notable for their sturdy simple construction, their ability to transmit heavy loads although requiring small space themselves and long trouble-free service, Fully described in Catalogue MDC/3.

Coventry Gauge
& TOOL CO. LTD.
COVENTRY, GT. BRITAIN

NEW DIECASTING MACHINE

The IMP/96 Diecasting Machine manufactured by Die Casting Machine Tools, Ltd., London, developed from the popular M55A/HF Diecasting Machine, has been proved to be an economic and extremely high output pressure diecasting machine for zinc, tin and lead. A new pilot-operated "Impact" Injection Unit has been introduced, together with a power-operated die locking and opening unit manipulated by finger-tip controls.

The "Impact" Injection Unit consists of a specially designed cylinder with a pilot-operated slide valve integrally built into the cylinder head. This unit is interlocked by means of a small valve at the side of the machine, which prevents it from being operated until the dies are closed and locked.

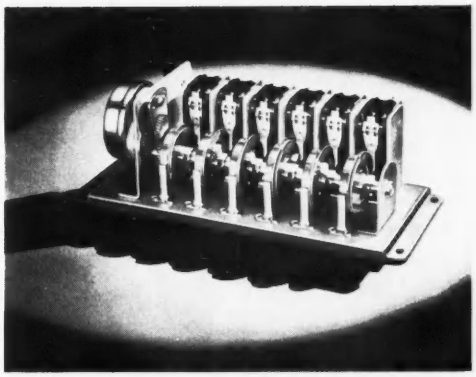


The power-operated die unit, which carries die blocks 6 in. × 9 in. × 1½ in. for an effective projected area of castings up to 12 sq in., has an opening of 4 in. and a formidable lock through four toggles of 12 tons, working through two hardened and ground heavy-duty tie bars of special steel. The unit is powered by an air cylinder which is of ample capacity to eject castings that offer stubborn resistance to ejection, and which is, at the same time, smooth in movement and economical in air consumption. The complete cycle takes only 0·55 cu. ft. of free air at 80/100 psi.

MULTI-CAM RECYCLING TIMER

The multi-cam recycling timer developed by Industrial Timer Corporation of Newark, N.J., offers an easily-operated, flexible, and outstandingly compact instrument for controlling industrial manufacturing and processing operations. A group of cams, operating snap-action switches, is mounted on a single shaft driven by a synchronous motor. Thus, all cams rotate simultaneously, and continuously repeat a constant time cycle that is common to all circuits.

Percentage calibrations on each cam face permit cams to be individually adjusted for ON and OFF electrical periods ranging from 2 to 98 per cent of the time cycle.

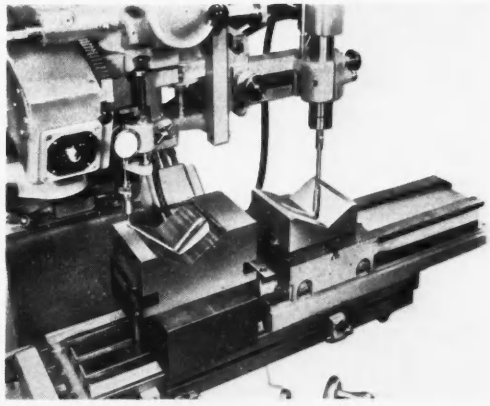


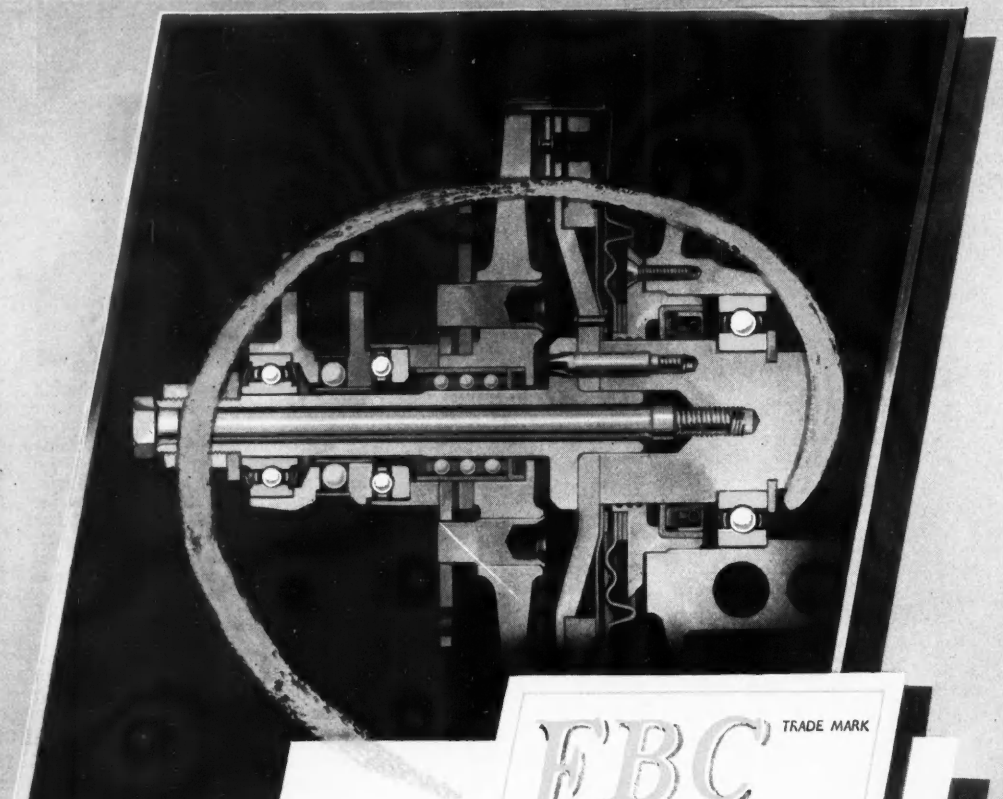
The time cycle can also be easily changed by substituting simple rack assemblies in the drive between the motor and cam shaft.

In addition, every cam is independently adjustable to permit a specific, over-all timing sequence to be obtained. This is accomplished by rotating each cam with finger pressure, using its drum calibrations for guidance. Elimination of cam followers and other types of moving parts makes this an extremely compact, simple-to-operate unit. Nine models are available, with time cycles ranging from 1 revolution in 40 seconds to 1 revolution in 72 hours.

REVERSE IMAGE ATTACHMENT

A Reverse Image Attachment for their Vertical Hydro-Tel Type Milling Machines has been announced by The Cincinnati Milling Machine Co., Cincinnati, Ohio. This attachment is employed for milling right or left-hand dies, moulds, and hobs from masters of the opposite "hand." Thus, with only one master, both right and left-hand matching halves of a die can be milled to perfect symmetry. The attachment is designed to be mounted on the machine table at the right-hand end, under the vertical depth control unit. It consists of a rigid supporting base which carries an auxiliary table on anti-friction rollers. At the rear of the attachment, a pair of matched racks, one on the supporting base and one on the auxiliary table, are engaged by a gear which is carried by a fixed bracket. The gear acts as an idler between the two racks, translating movement of the machine table to movement of the attachment table in the opposite direction. Therefore, a master shape mounted on the auxiliary table will be reproduced in the die block, but to the opposite "hand."





FBC TRADE MARK

ALL-BRITISH

Ball and parallel-roller bearings for every purpose.

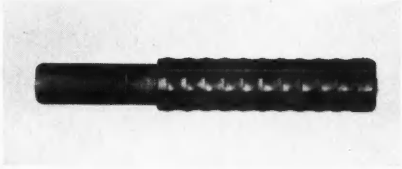
The illustration shows the servo-brake mechanism on two famous British cars, with F.B.C. sealed bearing, thrust race and X.L.S. type bearing.

FISCHER BEARINGS CO. LTD., WOLVERHAMPTON
Subsidiary of British Timken Ltd.
Works: Birmingham, and Duston Northampton

CORRECTION BROACH

B.S.A. Tools, Ltd., are now producing a special type of broach, its purpose being to correct any distortion which is apparent after case-hardening. Although many correction and burnishing broaches are already available, these are effective only before case-hardening. In view of the distortion which occurs during the case-hardening operation and the difficulties associated with this correction, it is not surprising that for many years manufacturers have been anxious to obtain a simple, inexpensive method of overcoming the problem.

The B.S.A. special correction broach has been produced after a great deal of research and experimental work to solve the problem of removing some thousands of an inch from clutch hubs and dog clutches which had undergone distortion in the splined bore during case-hardening.



After considerable research and experimental work, a push-type broach, suitable for use on a vertical press was made, and in consideration of the very high stress values which are encountered, the broach was kept as short as possible. The desired hardness was achieved and, finally, a liquid nitriding treatment was given in order to obtain a glass-hard surface. The broach was designed to burnish both the top diameter and the side faces of the splines. The distortion itself was rectified by pushing back the protrusion to the original level without removing any metal. This compressive action has no detrimental effect upon the material and there is no risk of the formation of cracks ; in fact, the compression tends to increase the surface hardness. Suitable for use on components after all carbon and carbon nitrogen case-hardening treatments, this special broach will correct distortions up to 0·005 in.

RUBBER FABRIC DRUM

United States Rubber Company has developed a new 55-gallon synthetic rubber-fabric drum, suitable for shipping liquids, which can be collapsed after emptying and is returnable and re-usable. The new drum should effect substantial savings in return shipping costs, since more than 2500 collapsed drums can be shipped in a standard railway wagon that would hold only 300 rigid drums.

Experimental tests made by United States Rubber Company indicate that the new drum will be suitable for the shipment of oils, greases, fats, acids, paints, emulsions, soaps, dry powders, and a variety of pharmaceutical and industrial chemicals. It is also believed to be practical for transporting liquids by air for the Armed Forces and for dropping liquids by parachute to ground troops. It is made of Ustex cord fabric, a strong low-stretch cotton textile, impregnated with synthetic rubber and moulded in one piece. The result is a tough, flexible, synthetic rubber-fabric drum approximating the size of a regular barrel or drum. It is equipped with simple yet effective fittings for filling, emptying, lifting, and handling.

The new type of drum is considered to have safety advantages, since it needs no venting while being filled or emptied, and therefore can eliminate hazards sometimes encountered in handling certain acids and liquid combustibles. Liquids that oxidise easily can be withheld from exposure to air during removal from the synthetic rubber-fabric drum.

SURGE DAMPING VALVE

New surge damping valves said to eliminate excessive shock in high-pressure hydraulic systems have been developed by The Denison Engineering Company, of Columbus, Ohio. They are individual units universally adaptable to any hydraulic circuit. Small and compactly designed, they are installed as easily as any ordinary fitting and do not interfere with other functions of the circuit. The valve has been proved in test set-ups over many months successfully to prevent shock from occurring, rather than simply absorb hydraulic surge and consequent shock.

Possible applications for this new Surge Damping Valve are reported to include : installation at the ports of 4-way valves ; in a cylinder circuit as an automatic decompression valve ; in any line leading from an accumulator ; and in other locations. Uniform acceleration ensures smooth, shockless action in the circuit, regardless of the pressure used. The valve adjusts itself automatically to any working pressure, requires only a fraction of a second to act, and cannot slow down cycle time. It prevents the damaging vibrations caused by sudden starting, or reversing flow.

Being small in size and light in weight, the valve has its simplified component parts compactly arranged. The spool inside is normally held closed by a spring to prevent flow from inlet to outlet. It moves to fully open position at a rate controlled by a small, built-in valve that is responsive to the difference between outlet and inlet pressures. This produces different opening speeds at various pressures.

An unusual feature of the valve is that it will open at a slower rate of speed at high pressures than at low pressures, when the valve is subjected to sudden surges of fluid. Also, the rate of flow will increase as the pressure in the outlet line of the valve approaches that at the inlet side.

NEW GASKETING MATERIAL FOR HIGH VACUUM

Under the trade-mark " Myvaseal," a new synthetic rubber gasketing material with very low vapour pressure has been announced by Distillation Products Industries, a division of the Eastman Kodak Company. The new material is a synthetic elastomer product which is quite soft and has a high abrasion resistance.

Under standard test conditions, the material has been found to have a lower outgassing pressure than any other material commonly available for this purpose. In most high-vacuum systems, it does not prevent attainment of pressures down to approximately 10^{-7} mm Hg. Myvaseal gasketing material is now being used for electron tube exhaust machines. It has resulted in longer-lasting tubes because its remarkably low vapour pressure means higher vacuum with less pumping. The latest television picture-tube pumping systems and rotary exhaust systems are also being equipped with this new material.

The new machinery catalogue

Send for your Copy Today—

More than 200 pages listing holdings of modern machinery (new, rebuilt and secondhand) from the most comprehensive stocks in the country—a catalogue which should be on the desk of every machinery user.

HAVE YOU HAD YOUR COPY?

★ The Albion Machinery Catalogue is completely revised every two or three months, and will be sent regularly as published on request.

ANOTHER ASPECT OF TWW SERVICE

THOS W. WARD LTD

ALBION WORKS · SHEFFIELD

TELEPHONE: 26311 (15 Lines) • TELEGRAMS: "FORWARD, SHEFFIELD"

LONDON OFFICE: BRETTENHAM HOUSE · LANCASTER PLACE · STRAND · W.C.2

G/23

CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns, are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

AERODYNAMICS

Drag Coefficient as a Function of Surface Roughness at Low Reynolds Numbers

By T. SZENTMÁRTONY. (From *Gép, Hungary*, Vol. 3, No. 1, January, 1951, pp. 42-46, 12 illustrations.)

THE problem of the influence of the surface finish on the efficiency of impeller blades has often arisen in the past. Compressor blades normally operate at fairly low Reynolds numbers, while aircraft propellers work at higher Reynolds numbers, at which the boundary layer is always turbulent ; consequently, the surface roughness greatly influences the drag. The present investigation is concerned with this influence at a Reynolds number of $1{\cdot}5 \times 10^5$.

An NPL-type wind-tunnel of square cross-section was employed, and an aerofoil of standard profile extended across the whole width of the tunnel, thus giving an effectively infinite aspect ratio. The effect of four different surface finishes was investigated by Jones' method, which gives the drag coefficient in terms of measured differences of impulse at surfaces far in front of and behind the wing. The wing was adjustable for different angles of attack between — 2 deg. and + 8 deg. A wind velocity of 20 m/sec was used.

The results of the experiments can be summarised as follows :—For normal angles of attack (4-6 deg.), the difference in drag coefficient between a polished and an aluminium-sprayed surface amounts to 5 per cent and probably increases with higher Reynolds numbers.

BEARINGS AND BEARING METALS

Oil-Pocket Metal Powder Bearings

By J. HALLER. (From *Materials & Methods, U.S.A.*, Vol. 33, No. 5, May, 1951, pp. 80-81, 2 illustrations.)

A RECENT development in the field of powder metallurgy is the production of parts such as bearings and bushings with interior cavities which serve as lubricant reservoirs. In such parts, the self-lubricating properties of the piece are prolonged five to six times that of conventional parts of similar types.

These oil-well bearings have a continuous cavity—or pocket—of uniform size and shape inside the wall. The opening can be produced in a varied range of sizes and shapes to meet the particular requirements of the part. As grease is impregnated into the sintered metal by static pressure, it fills this pocket as well as the pores in the sintered metal body itself. The result is that, in application to bearings as an example, the increased lubricating quality of the bearing, together with a stronger bearing material, makes it possible for the bearing to take heavier loads and practically eliminate " freezing " under the most adverse operating conditions.

The pocket feature lends itself to a wide variety of applications. As one example, gears have been produced in which the cavity is not only in the internal diameter but extends into the teeth to provide maximum self-lubrication in parts of this type. These gears, however, are not yet being manufactured on a volume production basis.

At the present time, the major volume of production is in pillow block bearings and self-aligning fan and blower bearings. Guide pin bushings, incorporating the wall reservoir cavity, are also being used with definite success, every test proving that there has been negligible wear on either the bushing or the pin and, of most importance, the pin has received adequate lubrication at all times, without any attention being required.

DIELECTRICS

On the Mechanism of the Electrical Breakdown of Solid Dielectrics

By D. V. ZERNOV. (From *Izvestiya Akademi Nauk, Russia*, No. 6, 1950, pp. 866-872, 1 illustration.)

IN this paper, the author deals with results of investigations on the electrical breakdown of very thin layers of solid dielectrics. The experiments were carried out with dielectric layers of thicknesses varying between 10^{-4} and 10^{-5} cm deposited on a metal base. From the results obtained, the author concludes that there is a definite similarity between the phenomena observed in the final stages of breakdown in the case of compressed gases and those occurring in thin layers of solid dielectrics. In his view, the breakdown is not a result of increasing conductivity prior to the final breakdown, but is due to the development of a single avalanche owing to impulse ionisation by the tied electrons of the lattice of the dielectric. In very thin dielectric layers, discharge phenomena occur which are similar to corona discharges in compressed gases.

Although the phenomena which occur in compressed gases if they are subject to the influence of a strong dielectric field are similar to those taking place in a solid dielectric under comparable conditions, the breakdown strength of solid dielectrics cannot be increased in the same way as it can be increased in the case of gases. To obtain an increased dielectric strength of a solid dielectric in this way, it would be necessary to reduce the thickness of the dielectric layer to such small values that a relatively small voltage drop across the layer may cause a rather large flow of current due to freeing of electrons from the dielectric layer by the intensive electric field, a process which is not related to impulse ionisation.

FIRE PREVENTION

Ignition Temperatures of Various Papers, Woods, and Fabrics

By S. H. GRAF. (From Bulletin No. 26 of *Engineering Experiment Station, Oregon State College, U.S.A.*, March, 1949, 66 pages, 27 illustrations.)

THE ignition temperatures of organic substances have been the object of research and contemplation for many years, but even so the existing information has been meagre and controversial. In the interest of more precise information with relation to public safety, this paper has been prepared from data obtained with semi-automatic apparatus carefully designed to give conditions easily duplicated and comparable to those that could exist in a storage warehouse or other building containing the materials in question.

Three classes of substances, paper, wood, and fabric, were tested under conditions of variable specimen weight, variable heating rate, variable air flow, variable atmosphere composition, and variable humidity, in an effort to obtain the minimum ignition temperatures. The general trend was towards lowered ignition temperature with increase in oxygen concentration of the

EIGHTEEN IN THIS HAND . . . and they're all ACES!

THREE TYPES

There are three Standard Types of the Cincinnati Dial Type Milling Machine: Plain, Universal and Vertical, and these are available in

THREE SIZES

in each type, so that a wide range of work in tool room or moderate production quantities can be accommodated by these versatile machines. Completing the range, each type and size is again available in

TWO SPEED

and feed ranges — high speed and medium. Dial type convenience, and ease of operation contribute to the variety of work which may be assigned to these machines. Streamlined design for easy cleaning; simple, effective lubrication and the acknowledged high standard of Cincinnati Construction are other factors which may be accepted in any preliminary consideration. Complete specifications will be promptly supplied on request.

CINCINNATI

Dial Type

MILLING MACHINES

CINCINNATI MILLING MACHINES LTD.

TYBURN, BIRMINGHAM, 24

Sales Representatives for Great Britain and Northern Ireland: Charles Churchill & Co. Ltd., Coventry Road, South Yardley, Birmingham, 25. *Sales Representatives for Eire:* Booth Bros. Ltd., Dublin.

atmosphere. There was in most cases an optimum air flow for the lowest ignition temperature, but there was little or no effect on the ignition temperature by low concentrations of water vapour, sulphur, and petrol fumes.

JET ENGINES

Bonding of Titanium Carbide with Metal

By W. J. ENGEL. (From *Metal Progress, U.S.A.*, Vol. 59, No. 5, May, 1951, pp. 664-667, 4 illustrations).

SOME materials which show considerable promise for high-temperature application in jet engines have been fabricated from combinations of ceramics and metals (the so-called " ceramals ") by the sintering process. This process affords a means of producing compositions at temperatures below the melting point of the ceramic constituent. Controlled sintering of a powdered ceramal compact is generally capable of producing satisfactory homogeneity and grain size. However, an investigation of the mechanisms for alloying or bonding of metallic and ceramic materials is necessary for the maximum utilisation of ceramals in aircraft power plants.

Consequently, an investigation was made at the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics to study the bonding of titanium carbide with various elements, and to accumulate information regarding the mechanism of bonding.

Of the fifteen elements tested, only nickel, cobalt, chromium and silicon bonded with solid, high-density titanium carbide. Nickel and cobalt produced the most extensive bonds; chromium and silicon were less effective in penetrating and forming extensive interlocking networks. The appearance of small, angular-shaped precipitates in the nickel-rich and cobalt-rich zones somewhat substantiated the premise that there is some solubility (limited perhaps) of titanium carbide in nickel and cobalt at temperatures above their melting points. Nickel, cobalt, and possibly chromium appear to have some promise as binder materials for sintered titanium carbide bodies.

METALLURGICAL ENGINEERING

Decomposition of Remanent Austenite at Sub-zero Temperatures

By G. A. ODING. (From *Hutnické Listy, Czechoslovakia*, Vol. 6, No. 3, March, 1951, p. 143, 4 illustrations, originally published in *Zavodkkaya Laboratoriya, Russia*, No. 4, 1950, pp. 475-479.)

STEEL specimens 130 mm long and 4·5 mm in dia. were heated to a suitable temperature and quenched in fluids held at 20° C, and then investigated in a dilatometer. The rates of cooling varied between 0·5 and 1·5° C per minute. For steel U12A (average compostion: 1·15 C, 0·20 Mn, 0·30 Si max., 0·20 Cr max., 0·25 Ni max., 0·03 S max., 0·03 P max.) and a cooling rate in the dilatometer of 0·5 to 1° C per minute, the dilatometric curve obtained shows a sudden noticeable elongation at about — 48° C, which indicates a transformation of residual austenite into martensite. This elongation continues during further cooling and suddenly ceases at — 116·5° C. It can be concluded from the dilatometric curve that a certain amount of residual austenite does not become transformed into martensite.

Chromium, chromium-tungsten and chromium-silicon steels were also investigated by the author and the dilatometric curves obtained are given.

The hardness of specimens which have only been hardened as well as specimens which have been both hardened and cold-treated (i.e., cooled in the dilatometer) was also measured, and the values obtained confirm the conclusions drawn from the dilatometric tests.

STEEL FOUNDRY PRACTICE

Investigation on the Penetration of Liquid Steel in Moulding Sand

By H. PETTERSON. (From *Jernkontorets Annaler, Sweden*, Vol. 135, No. 1, January, 1951, pp. 1-43, 27 illustrations.)

THE penetration of liquid steel in sand moulds was studied by immersing cylindrical test pieces of moulding sand into liquid steel in a high-frequency furnace. The influence of steel composition, temperature and pressure, and of grain size and grain size distribution of the sand as well as mould composition, ramming density and sintering temperature, was investigated. If the steel immediately solidifies on the surface and remains solid, no penetration can take place. If the steel remains liquid on the mould surface, penetration takes place provided the steel pressure is sufficient to overcome the capillary resistance. Generally, a pressure of about 10 cm of steel is necessary for coarse sand, and 40 cm for fine sand, to cause penetration. At constant pressure, the speed of penetration generally proceeds at a constant rate. At increasing pressure, the speed of penetration increases proportionally to the increase in pressure. The speed of penetration increases with increasing steel temperature. The speed is lower, the lower the average grain size of the sand, as time is required to break through constrictions in the pores. Normal variations in ramming do not appear to influence the penetration. A higher carbon content in the steel acts in the same way as a finer grain size of the sand. Sintering of the sand in certain cases appears to prevent penetration. Coating of the mould may also prevent penetration, provided the coating at the contact with the steel forms a layer that is practically free from cracks and holes.

ON THE MECHANISM OF DISRUPTION OF HIGH-ALLOYED STEELS DURING FORGING

(*Concluded from page* 220)

0·04 per cent P). The formation of non-uniform layers, similar to those described above, was observed during shaping at temperatures up to the A_1 point, i.e. up to about 700° C.

CONCLUSIONS

During the forging of alloyed steel by blows with flat hammers, localised overheating of the metal will occur at the planes of maximum displacement. The degree of overheating depends on the speed and degree of deformation and on the heat-conductivity of the shaped alloy. The higher the speed and degree of deformation and the lower the heat-conductivity of the material, the more intensive will be the overheating at the plane of maximum displacement. Such localised overheating will bring about a corresponding, localised, change of phase if the alloy has a tendency towards such changes of phase. In most high-alloy materials, the phase changes take place at fairly high temperatures and disrupt the existing crystalline structure of the material, thus reducing their plasticity.

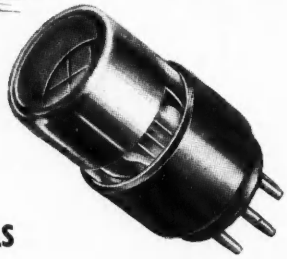
In the case of brittle high-alloy steels, the local overheating of a layer of the metal causes a change in structure, disrupts the bond between the crystals, and brings about crack formation and disruption of the material.

ERRATUM

HEAT TRANSFER WITH SUPERHEATED STEAM — In this article, published last month on p. 191, steam pressures were given in bars, and it was stated that 1 bar = 2·953 inches of mercury. This should, of course, read 29·53 in.

CINTEL

The most comprehensive range of Cells in the world



TYPE VTA
FLAT
TRANSPARENT
CATHODE

'CINTEL' PHOTO-ELECTRIC CELLS

are manufactured with three different types of cathode surface as follows:—

TYPE 'A' — Antimony-Caesium (British Patent No. 522,752, 1938) sensitive to daylight and blue light.

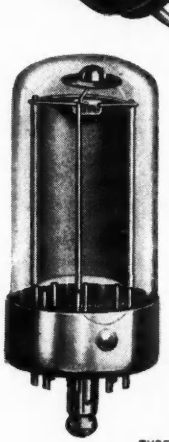
TYPE 'B' — Bismuth etc.-Caesium, sensitivity similar to that of the human eye.

TYPE 'S' — Silver-Oxygen-Caesium, sensitive to red-infra-red light.

There are over seventy different types covering every known application, and included in this range are:—

★Push-Pull types for double sound tracks. ★Special cells for dye image sound tracks. ★Cells of high insulation, linearity, and stability for accurate photometric work. ★Cells for use in the ultra violet region of the spectrum. ★Multiplier cells. ★Transparent cathode cells &c.

For further information, please write to:—



TYPE VS51
B8G BASE

TYPE VS50
B7G BASE

CINEMA-TELEVISION LIMITED

A Company within the J. Arthur Rank Organisation

FOREMOST IN THE MANUFACTURE OF

• Counters & Chronometers • Metal Detectors • Oscilloscopes • Photo-Electric Cells • Cathode Ray Tubes • Geiger-Muller Tubes • Electronic Instruments

WORSLEY BRIDGE ROAD · LONDON · S·E·26

Telephone: HITher Green 4600

SALES AND SERVICING AGENTS:

F. C. ROBINSON & PARTNERS LTD
287 Deansgate, Manchester 3

ATKINS, ROBERTSON & WHITEFORD LTD
100 Torrisdale Street, Glasgow S.2

H. HAWNT & CO. LTD
59 Moor St., Birmingham, 4

CINTEL
REGISTERED TRADE MARK

NEWS OF THE MONTH

PERSONAL

Mr. John Ayres, M.I.E.E., works director of the Brush Electrical Engineering Co., Ltd., Loughborough, has been appointed general manager of Petters Ltd., Staines, Middlesex.

Mr. C. F. Barnard has been appointed assistant general manager of the National Gas and Oil Engine Co. Ltd., Ashton-under-Lyne.

Mr. E. J. Batchelor, managing director of Brush Coachwork Ltd. and of A. C. Morrison (Engineers) Ltd., Loughborough, has been appointed vice-chairman of Brush Coachwork Ltd. and director and general manager of Henry Meadows Ltd., Wolverhampton.

Mr. J. A. Broughall, B.Sc.(Eng.), M.I.E.E., has been appinted executive officer (electrical engineering new works and development) at Railway Executive headquarters.

Mr. L. G. Burrows has rejoined Crypton Equipment Ltd. (a company in the Lancashire Dynamo Group) and has been appointed area manager for the Midlands and South Wales.

Mr. R. H. Cain, V.C. has been appointed general manager of the Shell Company of West Africa Ltd., with headquarters in Lagos.

Mr. Lewis Chapman, managing director of William Jessop & Sons Ltd., Sheffield, has been elected chairman of the Birtley Company Ltd., Birtley, Co. Durham.

Mr. D. G. Denoon, joint publicity manager of British Insulated Callender's Cables Ltd., and **Mr. C. H. Chaplain,** manager of the publicity department of the British Thomson-Houston Co., Ltd., have been elected chairman and vice-chairman, respectively, of the publicity committee of the British Electrical and Allied Manufacturers' Association, 36-38 Kingsway, London, W.C.2.

Mr. K. N. Eckhard, M.I.E.E., M.Inst.T., M.I.Loco.E., has been appointed director and general manager of Brush Bagnall Traction Ltd.

Mr. T. Campbell Finlayson, M.Sc. has been elected chairman of Woodall-Duckham Ltd. Mr. Finlayson is also chairman of Woodall-Duckham Vertical Retort & Oven Construction Co. (1920) Ltd., 63-77 Brompton Road, London, S.W.3.

Dr. R. Genders, M.B.E., D.Met., F.R.I.C., F.I.M., is now associated as consultant metallurgist with Messrs. Sandberg, 40 Grosvenor Gardens, London, S.W.1., in connection with their recently reopened analytical laboratories and test house.

Mr. B. D. Giordan, B.Sc., A.M.I.Mech.E., has been appointed general manager of Mirrlees, Bickerton and Day Ltd., Stockport.

Dr. Nicol Gross, A.M.I.Mech.E., has been appointed assistant director of research of the British Welding Research Association, 29, Park-crescent, London, W.1, but will remain in charge of the research station at Abingdon. **Dr. K. Winterton, B.Sc.,** and **Mr. H. E. Dixon, M.Sc., A.I.M.,** have been appointed chief metallurgists, the former for ferrous metals and the latter for non-ferrous metals. **Mr. C. L. M. Cottrell, M.Sc.,** and **Mr. P. T. Houldcroft, B.Sc.,** have been appointed assistant chief metallurgists for ferrous and non-ferrous metals, respectively.

Professor A. A. Hall, Zaharoff Professor of Aviation, London University, and Head of the Department of Aeronautics, Imperial College of Science and Technology, has been appointed director of the Royal Aircraft Establishment, Farnborough.

Mr. F. J. B. Henderson, B.A.(Cantab.), chief of the purchasing department and materials and supply officer, **Mr. C. H. Carslaw, B.Sc.(Glas.), A.M.I.Mech.E.,** technical director, and **Mr. T. L. Mackie, A.I.Mar.E.,** sales director, of Drysdale & Co. Ltd., Yoker, Glasgow, W.4., have been elected to the Board of the Company.

Mr. William Jones has been appointed manager of the Bristol office of Brookhirst Switchgear Ltd., Chester.

Mr. C. H. Lumley, O.B.E. has been appointed director of home sales (industrial) of Sigmund Pumps Ltd., Terminal House, 52 Grosvenor Gardens, London, S.W.1.

Mr. J. P. A. Meldrum, O.B.E., B.Sc., M.I.E.E., has been appointed special assistant, sales management, and **Mr. J. E. Stubbs, B.Sc., A.M.I.E.E.,** sales manager, Switchgear Department, of the Metropolitan-Vickers Electrical Co. Ltd., Mosley Road Works, Trafford Park, Manchester 17.

Mr. J. D. Morton, B.Sc., M.I.E.E., M.I.Mech.E., has been appointed a director of Siemens-Schuckert (Great Britain) Ltd., Great West Road, Brentford, Middlesex.

Mr. E. C. Ottaway, M.I.Mech.E., R.D.I. has been appointed chief supplies officer of the London Transport Executive, 55 Broadway, London, S.W.1.

Mr. W. F. Parker, M.I.E.E., has been elected national chairman of the Association of Supervising Electrical Engineers, 54 Station Road, New Barnet, Hertfordshire. **Mr. L. L. Emmett** has been elected vice-chairman and **Mr. E. J. Sutton** has been re-elected honorary treasurer.

Mr. J. E. Pegg, A.M.I.E.E., President of the Yorkshire (South-East) Branch of the Association of Mining, Electrical and Mechanical Engineers, has joined the Belmos Company Ltd., Bellshill, Lanarkshire, as representative for Yorkshire, Nottinghamshire and Derbyshire.

The Iron and Steel Corporation of Great Britain announce that **Mr. F. Scopes** has been appointed director and chairman of the Kettering Iron and Coal Co. Ltd., Kettering, in succession to **Mr. James Gough,** who resigned recently. **Mr. Scopes** has also been appointed chairman of the New Cransley Iron and Steel Co. Ltd., Kettering, in succession to **Mr. H. J. Ellison,** who has retired from the positions of chairman and managing director. The latter position has now been taken up by **Mr. G. H. Johnson. Mr. Edward Withington** and **Mr. N. W. Fischer** have retired from the board of Glynhir Tin Plate Co. Ltd., Pontardulais, Glamorgan; **Mr. W. S. G. Rees** has been appointed chairman and **Mr. O. J. Thomas, Mr. Ivor Lewis** and **Mr. E. Arthur Withington** have been made directors.

Mr. V. G. Shepheard, M.I.N.A., who has been deputy director of Naval Construction since 1947, will succeed **Sir Charles Lillicrap, K.C.B., M.B.E., M.I.N.A.,** director of Naval Construction, Admiralty, who is retiring on September 30.

Mr. A. Neville Spriggs, O.B.E. has been appointed general manager of Hawker Aircraft Ltd.

Mr. W. A. Sycamore, M.I.N.A., M.I.Mar.E. has been appointed defence programme manager of Davey, Paxman & Co. Ltd., Colchester. **Mr. H. V. Stead, M.Sc.** has been appointed commercial manager (engines), **Mr. H. P. Brown,** assistant commercial manager (engines), and **Mr. J. A. Bennett-Powell, B.Sc., A.C.G.I., A.M.I.Mech.E.,** traction sales manager.

Mr. A. J. Thompson, M.Inst.F., A.M.Inst.Gas. E. has been appointed technical representative and engineer of The Dowson & Mason Gas Plant Co. Ltd., Levenshulme, Manchester 19, and will be responsible for the Company's activities in London and the Southern Counties.

BUSINESS NOTES

Burgess Products Co. Ltd. announces that the address of the Micro Switch Division of the Company is now at Dukes Way, Team Valley, Gateshead 11. Tel. No.: Low Fell 75322/3.

Durex Abrasives Ltd., the well-known abrasive manufacturers, have changed the name of the company to Minnesota Mining & Manufacturing Co. Ltd. (formerly Durex Abrasives Ltd.). The

Courtesy of Mather & Platt Ltd.

A 32-page booklet covering this and many other applications of the process will be sent on written request to responsible enquirers.

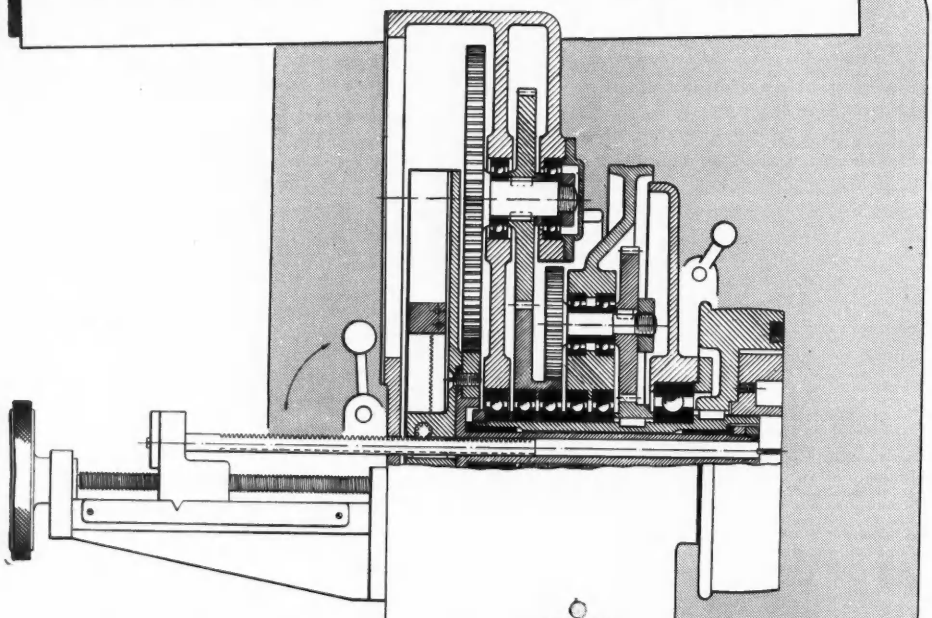
These impeller shafts (dia. about 6 in.) for large centrifugal pumps have been given ·008/·010 in. on radius hard chromium deposit by the Brailey Process. They will resist wear, abrasion and corrosion in a manner far superior to unprotected shafts.

Have you a product which needs this type of protection?

BRAILEY ELECTROPLATERS LIMITED
CHAPEL STREET · SALFORD 3 · LANCS · Tel. BLAckfriars 3341/2

855

The head holds the secret!



BENRATH

TYPE 'HAK'

HIGH PRODUCTION

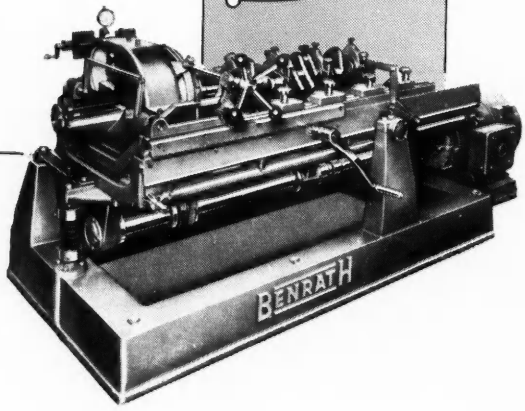
DYNAMIC BALANCING MACHINES

The head of the Model 'HAK' semi-automatic balancing machine holds the "mechanical brain" which faithfully, silently . . . and with unvarying accuracy directly records the phase and amount of unbalance.

Simple, robust construction ensures trouble-free service, combined with exceptionally rapid operation.

Seven sizes are in regular production for work up to 2 tons in weight.

Full details gladly sent on request.



BENRATH MACHINE TOOLS LTD · MANCHESTER 16

TELEPHONE: TRAFFORD PARK 2601·2

establishment, personnel, and the high quality products of the Company have not been changed in any way. The Durex names associated with the new Brand names are being publicised in the trade press, and any doubtful points will receive immediate attention from the Headquarters of the Company.

It is requested to order Durex Brand commodities by their new names, in order to facilitate the change over. Enquiries should be addressed to the Minnesota Mining & Manufacturing Co. Ltd. (formerly Durex Abrasives Ltd.), Arden Road, Adderley Park, Birmingham 8.

Flexible Drives (Gilmans) Ltd., 195 High Street, Smethwick 41, Staffordshire, have made a genuine effort towards arresting the upwards trend of living and production costs by their guarantee to maintain prices of all their manufactured products at the present level which has been maintained for the past four years. This applies to their complete range of " Multiflex " Flexible Drive Machines and Flexible Drives, " Skatoskalo " Boiler Descaling Apparatus and " Tite-Grip " Rotary Milling Cutters and Files.

The Esso Petroleum Company Ltd., will build a new major plant for the manufacture of sulphur at Fawley, near Southampton. Work on the plant is to start soon and when it is completed, early in 1953, it is expected to produce about 12,000 tons of 99·5% chemically pure rock sulphur a year. Almost all of this will be available to other industries.

This new development will help considerably in making up the present gap in sulphur supplies.

The project forms the third stage of construction at the new Esso Refinery, now being built at Fawley, which will eventually have an annual output of over six million tons of petroleum products. The first two stages comprise the building of the main refinery units for the production of fuels and lubricants.

The new refinery has been designed to extract from crude oil the maximum quantity of sulphur economically available in the refining operation and, at the same time, to use as little sulphur as possible in its various treating processes. In these processes no sulphuric acid whatsoever will be used and for a refinery of such size and complexity using crude oil from the Middle East, Fawley may well have the lowest sulphur requirements of any in the world.

The new plant will convert, by means of a controlled oxidation process, the sulphur which is released in the refining of the crude oil. This process is particularly interesting because it actually turns a disadvantage into an advantage, for Middle East crude is characterised by a higher sulphur content than crude oil from other parts of the world and a proportion of this sulphur has in any case to be removed from the refined products.

The Clarkson Thimble Tube Boiler Co. Ltd., of 15, Fetter Lane, London, E.C.4, completes twenty-five years' service to the Shipbuilding and Engineering trades in July 1951.

During that time, over 600 Clarkson Marine boilers of all types have been fitted to Diesel engined ships for waste heat recovery and as oil fired units.

The total number of Clarkson boilers of all types supplied during this period, for both marine and industrial installations, exceeds 3,700.

Foster Transformers & Switchgear Ltd., London, S.W.19, has found it impossible to deal with the greatly increased volume of orders at their Wimbledon factory. Arrangements have been made, therefore, to transfer production to Crypton Equipment Ltd., another factory in the Lancashire Dynamo Organization. The Crypton factory at Bridgwater, Somerset, newly built on a seven acre site, can provide the increased production space required and can also offer scope for factory extensions.

Dunlop Cotton Mills Ltd., Rochdale, are to establish a factory in Londonderry, Northern Ireland, for the production of rayon cord to be used in the manufacture of rubber tyres of all types.

The Coal Utilisation Joint Council have removed their offices to 3, Upper Belgrave-street, London, S.W.1. (Telephone : SLOane 9116).

Fifth Canadian International Trade Fair. Mr. Glen Bannerman, director of the Canadian International Trade Fair, on the authority of the Rt. Hon. C. D. Howe, Minister of Trade and Commerce, has announced that the C.I.T.F. will be continued in 1951.

The Scottish Conference of Incorporated Plant Engineers will be held at Dunblane Hotel Hydro, Perthshire, from Friday, October 5th to Sunday, October 7th.

At the Saturday morning session addresses will be given by the President of the Institution, **Mr. D. Lacy-Hulbert, B.Sc., A.R.I.C., A.I.Mech.E., M.Inst.F.,** and **Mr. J. F. Field, B.Sc., M.I.Mech.E., M.I.E.E.,** Controller of the South-East Scotland Division of the British Electricity Authority ; on Sunday morning **Mr. L. G. Northcroft, O.B.E., B.Sc.(Eng.), M.I.Mech.E., M.I.H.V.E., F.I.Plant E.,** will be speaking on " Coal and Europe."

An attractive social programme includes Dinner and Dance, as well as coach tours and golf.

INTERNATIONAL WELDING CONGRESS

The first Congress organized by the International Institute of Welding opened with a Government Reception at Lancaster House on July 14. Close on 500 delegates have enrolled, drawn from the welding experts of 21 countries.

The technical meetings, which will be held in Oxford from 16 to 20 July, include open sessions for the discussion of papers on The Welding of Bridges and Structures, The Welding of the Wrought Light Alloys, and Recent Developments in British Welding, at which the Chairman will be Professor F. J. Baker of Cambridge University, Sir Arthur Smart and Sir Donald Bailey respectively. On July 20 there is to be a whole-day Plenary Session, at which the

CLEAN OIL-FREE AIR

The Hymatic diaphragm air compressor unit provides air free from oil vapour and is therefore especially suitable for raising liquids which must remain uncontaminated, as well as for other purposes. It is compact and requires neither lubrication nor upkeep of any kind. The free air delivered is 1 c.f.m. at 10 p.s.i. (for liquid displacement this is equivalent to 200 gallons per hour). The maximum air pressure is 30 p.s.i. The Hymatic diaphragm air compressor has many applications in laboratories, food processing plants and so forth. There are three models available, Type DP.6 as illustrated is electric motor driven. Type DP.8 is pedestal mounted and belt driven. Type DP.9 can be used as a vacuum pump. Please send a postcard for leaflet HEC.541/56.

Hymatic

DIAPHRAGM AIR COMPRESSOR

THE HYMATIC ENGINEERING CO. LTD., REDDITCH, WORCS

Chairman of the Institute's fourteen technical Commissions will report on their work.

A technical film show, visits to the Cowley works of Morris Motors Ltd. and the Pressed Steel Co. Ltd., and to the Abingdon laboratories of the British Welding Research Association, together with numerous social functions and expeditions complete the full programme planned under the Presidency of Sir William J. Larke, K.B.E.

The following week the members of the Congress will be visiting works and shipyards in all parts of the country.

PARIS MACHINE TOOL EXHIBITION

The Machine-Tool Exhibition which is to be held at the Porte de Versailles, Paris, September 1st to 10th next will cover machine tools exclusively. The arrangement will be by classes of machine rather than by makers (or by agents as is sometimes the case) so that all lathes will be grouped together, whilst planers, millers, and grinders will all be found in their appropriate sections. This arrangement, it is considered, will considerably facilitate the investigations of potential purchasers.

Largely as a consequence of the demands made by the new defence programme upon their capacity, the participation of British makers will be comparatively insignificant. The importance of the exhibition, however, is enhanced by the growing need for machine tools, a need which has led to the recent relaxations in import restrictions and the increased activities of importing houses in this country and elsewhere, with their ever-growing lists of continental agencies. The exhibition is strongly supported by machine-tool makers in Belgium, France, Germany, Italy, Switzerland, Sweden, and other countries.

BRITISH PURCHASING COMMISSION TO EUROPE

The European Purchasing Commission which has been set up by the Minister of Supply (Mr. G. R. Strauss) to encourage procurement in Europe of stores and equipment required for the United Kingdom's defence programme, has now opened its main European offices.

The Directors of these offices and their addresses are :—

BELGIUM : Mr. Norman W. Doley, 107 Rue Belliard, Brussels.
GERMANY : Mr. A. S. Radford, 5 Mehlemer Strasse, Marienburg, Cologne.
FRANCE : Sir Charles Henderson, K.B.E., 116 Bis Avenue des Champs-Elysees, Paris (8e).
ITALY : Mr. W. Rogerson, Via Borgonuovo 10, Milan.
SWITZERLAND : Mr. Max Binney, St. Peter Strasse 11, Zurich.
SPAIN : Mr. W. Maude (Representative), c/o H.B.M. Embassy, Calle Fernande El Santo 16, Madrid.
DENMARK : Mr. A. K. Duthie, O.B.E. (Representative), Gentofte.

EXPERTS SEEK NEW FUEL FOR JETS

As the Royal Air Force, the Royal Navy and the civil airlines gradually turn over to jet aircraft, the demand for large quantities of special gas-turbine fuel is becoming urgent. The standard fuel for jet aircraft in this country is kerosine but its supply is limited. Oil experts now believe that the time has come to introduce a new turbine fuel—at any rate for military planes—which will be more plentiful.

Like most other spirits, kerosine is extracted from crude oil. But it represents only a fraction of the crude—some seven to ten per cent. If some of the other " fractions " of the crude oil, motor spirit or gas oil, could be included, much larger quantities of gas-turbine fuel would be available.

All British engines have been built so that they are capable of running on ordinary aviation spirit, but although large quantities of this can be refined, its use in high speed jets is limited. The main disadvantage is that it boils at low temperatures and atmospheric pressures. In other words, as the jet aircraft climbs up above the weather, the fuel in its tanks will begin to boil and much of it lost overboard through the vent pipes. There are, of course, ways of stopping this—by pressurizing the fuel tanks or providing gas outlets—but they increase the weight, cut down the amount of fuel which can be carried and restrict range.

Again, using ordinary spirit rather than kerosine means more risk of fire. Because of the low flash point of kerosine, designers have been able to put fuel tanks in places where they would never have put aviation spirit : integral tanks in the wings, for example, are becoming very much more common.

These are some of the difficulties of adding the lighter fractions like aviation spirit to the new fuel. The amount of heavier oils which can be used is also limited. One reason is their relatively low freezing point—which means that the fuel tanks have to be heated and more weight added.

What experts are now seeking is a fuel which will retain the good properties of kerosine and yet be simple to refine in large quantities.

PLANS FOR JET-POWERED ROTORS

Five of the 20 main British aircraft construction companies are now building or planning to build helicopters. The latest constructor to open a helicopter division is Percival—builders of the *Prince* feederliner. Two others, Bristol and Westland, have helicopters coming regularly off their production lines and two more, Fairey and Saunders-Roe, are building prototypes. Saunders-Roe recently acquired the helicopter firm of Cierva.

Helicopters with one and two piston-engines are in production and plans are going forward for much larger machines, driven by jet engines, for carrying up to 100 passengers or 15 tons of freight.

Several leading engine companies are working on the design of power plants for new helicopters. Alvis are already in quantity production with *Leonides* piston-engines for the small Royal Navy *Dragonfly* helicopter and for the four seat Bristol *Sycamore* and for the bigger two engine *Bristol* 173 for British European Airways. Alvis are now considering building a double *Leonides*. This will enable twin engines to be fitted easily into the larger helicopters.

Another piston-engine company, Blackburn, has converted its *Bombardier* engine for use in a new version of the Cierva *Skeeter*.

Gas-turbine engine constructors are planning how to adapt their engines for the new helicopter designs. Two British turbo-props, the Rolls-Royce *Dart* (1,400 h.p.) and the Armstrong Siddeley *Mamba* (1,475 h.p.) have already been suggested as possible power-plants for the new generation of jet-powered helicopters.

Design studies for these large jet-powered helicopters have been prepared by several firms. Westlands have announced plans for a machine with three large or six small jet engines, capable of carrying 100 fully equipped troops. This helicopter, the *W*-85, would weigh 80,000 lb. (equal to a *Lincoln*) with rotor blades 110 ft. across (about the wing span of a *Halifax* bomber). Its blades would be whirled round like a catherine wheel by jets coming from the blade tips. A smaller helicopter with two jet engines, the *W*-81, is also planned. It could carry 32 passengers at about 150 miles-an-hour.

Faireys have begun preliminary development work on a helicopter driven by two gas-turbines. It is a 23-seater, with a cruising speed of 134 miles-an-hour. The two engines will be fitted outside the fuselage, not inside as in all present helicopters. The air-jet will flow out to the tips of the blades. Also fitted to the blade tips will be little reaction units which can be turned on to give extra power for take-off and landing.

The Institution of Electronics Sixth Annual Exhibition will be held at the College of Technology, Sackville Street, Manchester 1, on the 24th, 25th and 26th July. Its object is to bring to the notice of all who are interested in electronic devices the progress which has been made during the previous year. Unlike its London counterpart, however, the Exhibits are not confined to new developments but include a wide and representative range of instruments of general use in research and industry.

" Superspeed " White Flash Activated Rosin Cored Solder. This cored solder was designed primarily to provide the essential safeguard against the formation of defective soldered joints. It contains a non-corrosive chemically activated rosin-based flux which accelerates the process of soldering by imparting a more vigorous fluxing action to the rosin. This increased fluxing activity makes it certain that even oxidised or contaminated surfaces will be perfectly soldered.

An important advantage is the design of the core—a " stellate " pattern with six flutes, each radiating from a central core to a point much closer to the periphery of the solder. Part of the flux core being located nearer to the outside surface of the solder enables the heat to penetrate more quickly and this results in an earlier liberation of the flux. The design of the core does not impair the normal mechanical strength of the solder wire.

A particular feature of the activating medium incorporated in the flux core is its solubility in rosin, ensuring its perfectly even distribution.

Classified Advertisements.

The rate for all classified advertisements is 6d. per word ; in bold print 9d. per word ; minimum order 6s. Box number advertisements 1s. extra. Instructions together with remittance must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

ASSISTANT WORKS MANAGER required for factory engaged in the light engineering industry, located in Scotland (East coast side). Applicant must be a practical engineer with experience in modern production techniques to assist in the control of existing processes and productions, and in the design and lay-out of new lines. Must have had experience in organisation and control of both male and female labour and accustomed to working on own initiative. Write stating age, qualifications, experience and salary required to Box No. E.D.B. 1.

PRODUCTION ENGINEER required by manufacturers of light electro-mechanical Engineering products in Scotland (East Coast side). Responsibilities would include taking control of flow line production units and design and development of new units. Experience in modern engineering production technique essential, with a good knowledge of latest jig and tooling methods. Applicants should detail age, experience and salary required to Box. No. E.D.B. 2.

MACHINERY, ETC., FOR SALE

NISSEN TYPE HUTS, ex-Government stock, reconditioned supplied ready for erection. Sizes in 12 ft. multiples, 36 ft. by 16 ft., £80 and £60 ; 24 ft. by 16 ft., £56 and £42 : 72 ft. by 16 ft., £150 and £109. Plasterboard huts and other buildings. Write, call or telephone, **Universal Supplies (Belvedere) Ltd.,** Dept. 50, Crabtree Manorway, Belvedere, Kent. Telephone ERITH 2948.

WANTED

WANTED.—Back issues of THE ENGINEERS' DIGEST for February and March, 1951, urgently required. Full price, 3/6 will be paid for each copy. Send copies to the **Subscription Department, " The Engineers' Digest,"** 120, Wigmore Street, London, W.1.

MISCELLANEOUS

TRANSLATIONS (Technical, Commercial), all languages. Abstracts also supplied. **Olympia Translation Service,** 149 Blythe Road, London, W.14. RIVerside 5135.